Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, OCTOBER, 1903. No. 8.

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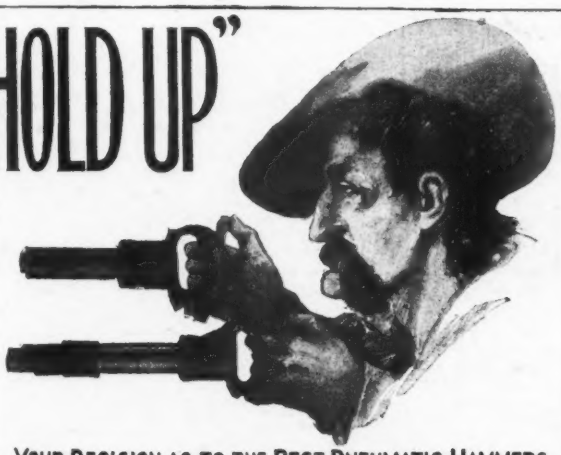

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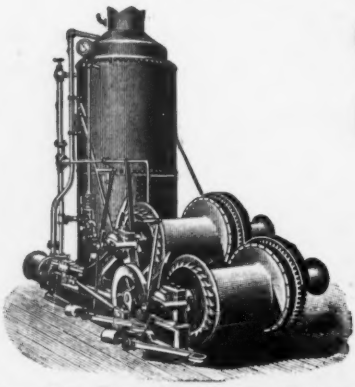

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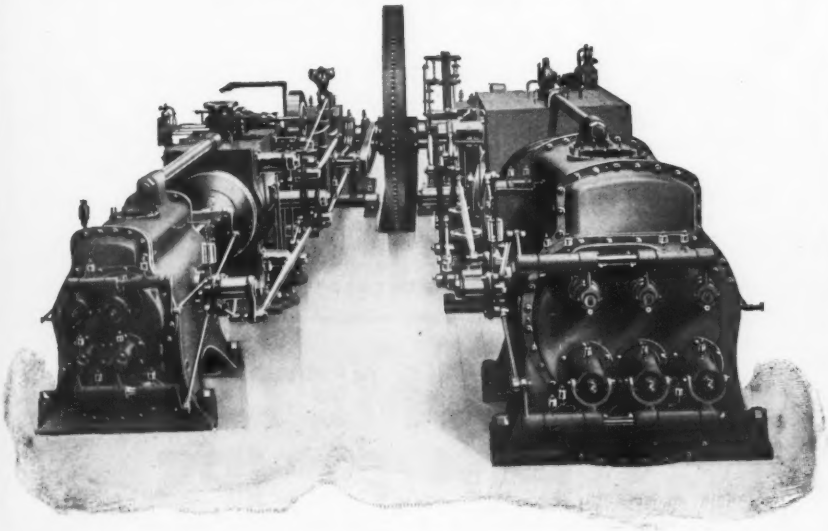

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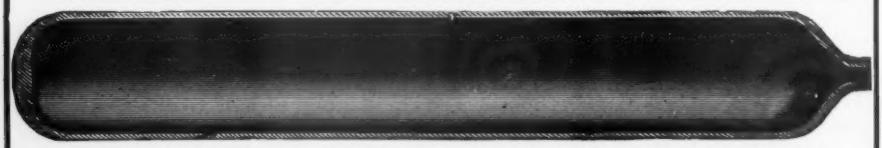

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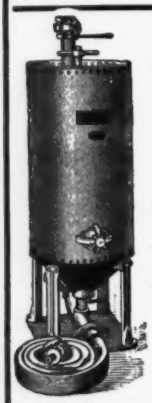

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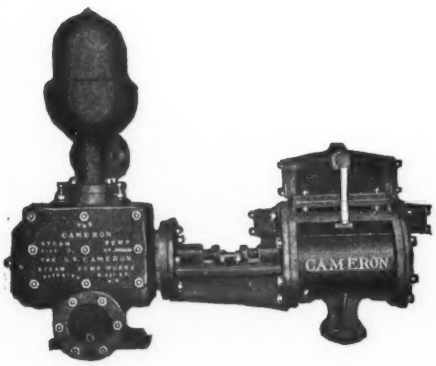

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VOL. VIII. OCTOBER, 1903. NO. 8

Improvements in Methods of Tunneling.

While the uncertainties of a ferry service to transfer passengers and freight across the Hudson river to New York still remain to vex and trouble, the importance of securing some other method than by boat has long been realized, and schemes to either bridge over or tunnel under the broad river were devised several decades ago. The first actual steps toward the practical solution of the problem were made in 1879, when a tunnel to connect Jersey City and New York was begun. The enterprise began auspiciously but, on account of financial trouble, which ultimately resulted in checking its progress, was many years delayed. Public attention is now once more directed to it, and there is every reason to believe that this tunneling enterprise, with several other similar projects, will soon be brought to a successful culmination.

The comparison of the methods used when the Hudson river tunnel was started in 1879 with those which have followed in the present operations serve to show very clearly the progress that has been made in tunneling methods. In no way is this progress more evident than in the changes that have come in the air compression machinery, which plays such an important part in this subaqueous tunneling enterprise. To assist in illustrating this point is the article which appears in this issue of COMPRESSED AIR telling, among others, of an old type of air compressor which was used in the construction of the Hudson river tunnel from the start of that enterprise in 1879 till the work was temporarily abandoned in 1891. It presents a striking contrast to the compressors now used for the tunnel work as described in an article in the September issue of COMPRESSED AIR, reprinted from the *Engineering Record*, which gave a detailed description of the present operations under the charge of Chief Engineer Jacobs.

Most important among the improvements to the compressor, which particularly apply to the construction of a subaqueous tunnel, is the compounding of the air cylinders. By this method the air is not burned, and the odor of burned oil once complained about disappears entirely. The compounding of the air cylinders with an inter-cooler between them permits a high compression without great heat, which invariably accompanied the old method.

Of considerable importance is the change in the manner of cooling the compressed air. The old plan of injecting water directly into the cylinder has been almost entirely replaced by water-jacketed cylinders and heads, which serve to cool the air almost as effectively and greatly diminish the wear on the cylinder itself, as well as simplifying the compressor and the draining of the air receiver and pipes. In the air valves as well the progress of the last score years is very noticeable. For

inlet valves, those of the piston type have demonstrated their value in a great majority of cases. Improvements in the poppet type of valves have also come with time. Then there are a host of minor changes, which, valuable in themselves, are but working for a common end, with the result that the air compressor of to-day is a far more efficient and yet much simpler machine than ever before.

The Development of the Straight Line Air Compressor.

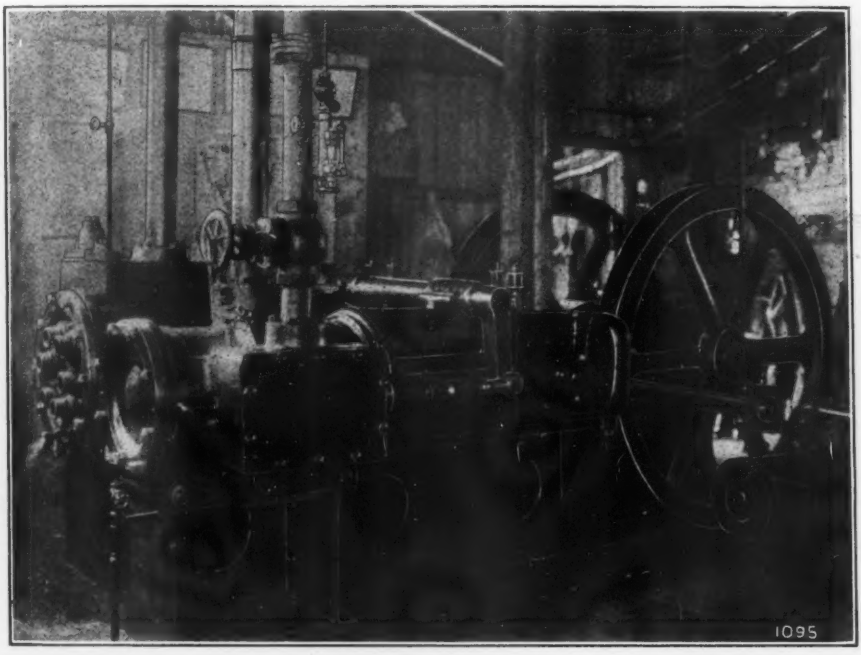
In New England, noted for the longevity of its citizens, one sees very frequently the parents, children and grandchildren living together under the same roof, but the only time the writer ever had the pleasure of meeting this condition in an air compressor plant was at one installed by Mr. Chas. Haskin, contractor, to conduct operations in the pneumatic tunnel at Jamaica Plain, one of the suburbs of Boston. If it were not for the fact that these machines had done good service in many of the Eastern States, one might be inclined to think that the bracing climate, and good habits of the New Englanders had challenged these venerable compressors to uphold the reputation of the manufacturer by establishing for themselves a record-breaking career. Besides one's interest in everything which has done good service, this plant would attract attention from the fact that these compressors, the product of the same manufacturer, are all of the straight line, self-contained type—each representing in itself a distinct period in the development of this class of machine.

In Figure 1 is illustrated the earliest type: here you will notice that the position of the air cylinder is quite different from that of the modern machine, being placed close to the steam cylinder. Between it and the steam cylinder is passed the main shaft upon which is mounted the necessary eccentrics to drive the steam valves and so forth. The crosshead, as you will see, is carried out

NO. 1—EARLIEST TYPE OF STRAIGHT LINE COMPRESSOR.

to the opposite end of the machine from the steam cylinder. You will also note the water injection pump placed on the side of the air cylinder which is operated from an eccentric on the main shaft. By means of this injected water the necessary cooling is produced, the cylinder not being water jacketed. The air cylinder is fitted with poppet inlet and discharge valves of quite a different construction from those in modern machines. The steam valves are of the regular Meyer cut-off type.

Figure 3 is a cut of the present type of straight line machine. The construction, on the whole, is very similar to illustration No. 2, the greatest difference being in the air cylinder. In this machine

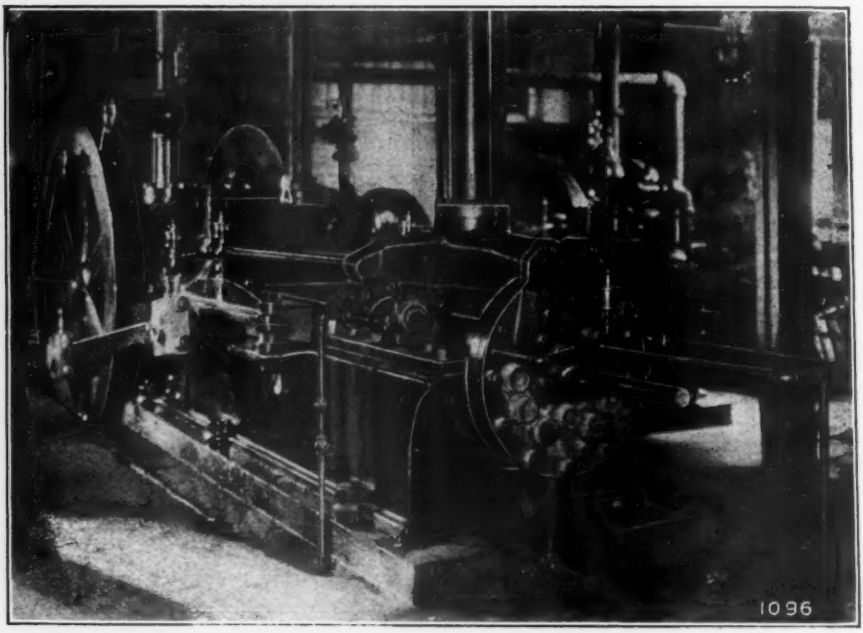


NO. 2—SIDE VIEW OF SOMEWHAT IMPROVED TYPE OF STRAIGHT LINE COMPRESSOR.

Figure 2 shows the next period of development. Here you will note the relative position of the steam and air cylinders, the crosshead and guides being placed between them, and the main shaft being placed back of the steam cylinder. Besides the very different arrangement of details in this machine from that of the former type, there is also a marked improvement in the type of air valves. The air cylinder, as formerly, is of the water injection type, the pump being operated from the crosshead. The valves are poppet inlet and discharge. A tail rod is carried through the back-head of the air cylinder. The entire machine when compared with its predecessor is much simpler in construction and more accessible for repairs and oiling.

the water injection pump is dispensed with, the air cylinder and heads being jacketed, and in place of the poppet inlet valves, a piston inlet type has been adopted. The discharge valves of the poppet type are placed in individual sockets, which facilitates any necessary inspection and increases the safety of operation. Again the crosshead is built on the swivel block principle, the rods being screwed into a coupling block placed in the centre of the crosshead, which is a

hollow steel casting. Through the centre of the crosshead and through the coupling block is passed a vertical pin. This construction adjusts itself to all uneven wear in the connecting-rod brasses, thus equally dividing the load on the pins, preventing any lateral strain on the connecting and piston rods. Where possible, many of the working parts have again been made more accessible and simplified in their construction, while the adoption of the latest processes of manufacture and the wide experience gained as to the proper materials to use in construction should make this



NO. 3—MODERN TYPE OF STRAIGHT LINE COMPRESSOR.

type a worthy descendant of its venerable predecessors.

Mr. Haskin very kindly supplied the writer with a history of these compressors, extracts of which may be of interest.

"No. 1 was bought by D. C. Haskin and used at the Hudson River tunnel from 1879 to 1891. During that time it was in use night and day for about three years. I bought it in January, 1893, and used it on pneumatic work continuously for the Commonwealth of Massachusetts until March, 1895; from March 10, 1895, on the pneumatic tunnel under the Providence River until October 15th of that year.

"No. 2 was purchased in 1881, and used in conjunction with No. 1. From June, 1896 to July, 1897, rock drills on the Neponset Valley sewer were run by it night and day. No. 1 was employed on the pneumatic work of completing the Buffalo intake tunnel from June to October, 1897, inclusive; No. 2 being on the same work from August to October.

"Both machines were used in building three pneumatic tunnels for the Massachusetts Pipe Line Gas Company from March, 1898, to June 1899, inclusive. They were again on pneumatic tunnel for the Metropolitan Water Board from Chelsea to Charlestown from October, 1899, to March, 1901. No. 2 was used in doing a small tunnel at Rockland, Maine, for two months during 1901. Both machines were started on pneumatic work for the Metropolitan Water and Sewerage Board, April 1, 1902, and have been running constantly to date, April 23, 1903.

"In all places where they have been running the work has been unremitting and on the present work they have not been shut down more than five hours each, in all. They have the original brasses, and some of the valves are those which came with them when bought. They have never been in a shop for repairs; the cylinders are in good condition. The piston rings in air cylinder have been renewed twice."

This certainly shows a very remarkable record of endurance and brings before us the fact that with proper attention the life of a well-constructed air compressor should be almost indefinite.

R. S. CARTER.

Transmission of Power by Compressed Air.*

Although used in isolated cases for a much longer period, the general employment of compressed air as a means for transmitting power or converting it into more manageable forms may only be said to extend back some fifteen years. Primarily confined to a very limited scope, the area of usefulness served by compressed air has yearly widened, and it is still continuing to make very rapid strides.

It is an undoubted fact that we are indebted to American engineers for the present improved condition of compressed air engineering, although many of the most important solid improvements—at any rate, in compressors—have been evolved in this country, the adoption of reciprocating rock drills, and the further spread of the use of these to so many shop tools owes most to the United States.

At the same time it is satisfactory to note that within the last few years a distinct change has been noticeable in the attitude of English engineers toward compressed air. Formerly it was regarded as quite an outside line of manufacture, confined to a few firms which could be counted on the fingers of one hand. But things have changed to such an extent that there are now quite a large number of firms making a specialty of both compressors, motors, and special tools.

The more compressed air is used the more rapidly will its use spread, because when an installation is once put into a workshop and the compressed air is there—as it were "on tap"—new uses will be continually presenting themselves, and the owner of the factory will soon find out new uses to which he can put this useful medium.

The position of compressed air is a peculiar one among other methods of transmitting power, inasmuch as it possesses advantages which render its use almost imperative for many kinds of work.

In the first place, the material or medium of transmission is the atmospheric air, of which there is everywhere an inexhaustible supply, which does not suffer any deteriorating effects in its use, and is therefore available for ventilating the space around the motor when it has done its work and been discharged. It is this quality which makes compressed air so especially suitable for transmissing power to the working faces of mines and tunnels.

The medium of transmission in this case, then, costs nothing to the user, but it requires pipes to retain and convey it.

In speaking about compressed air machinery it is usual to speak of "free air" as opposed to compressed air. By free air is meant the air at the pressure of the atmosphere in which the air compressor is working. This, at the standard barometric pressure of 29·98 inches of mercury, has a pressure of 14·7 pounds on each square inch exposed to it, and this pressure may vary with the variations of barometric pressure at the one place, and it gets smaller the further the compressor is raised above sea level. For instance, while the pressure is somewhere about 15 pounds per square inch at sea level, it falls to about 10 pounds at an altitude of 1,000 feet above the sea. So that "free air" does not mean necessarily air at any definite pressure, but simply air at the pressure to which compressed air will fall when released from pressure and allowed to go free at the point in question.

If this is free air, then it may be said that any of this free air which is forciby diminished in bulk, and consequently raised above this pressure of the free air, is "compressed air."

Another great advantage which com-

*Paper by W. C. Popplewell, M. SC., A. M. Inst. C. E., in *The Mechanical Engineer* (Eng.).

pressed air possesses is that its density is comparatively low, and this enables it to be sent along the pipes from point to point without any ill effects being felt from the inertia of the moving column of air. In this it is far superior to water. Besides the first cost of the water itself, it must only be allowed to flow along its pipes at a very slow speed, for if the speed were to be great any sudden stoppage of the column of water would lead to a great increase of pressure, with possible danger to the pipes; also, the friction of the water in the pipes is so very much greater than in the case of air for the same speeds. This advantage of air as compared with water is of still greater importance in the working of high-speed reciprocating motors. At the present time a very large proportion of the compressed air used in engineering work is employed for working high-speed reciprocating tools making many strokes a second, and it is obvious that a practically inelastic, heavy fluid like water could not possibly be used in these, and it is only with air that it is possible to obtain the rapid succession of admissions, expansions, and exhausts which are needed in machinery of this class.

The Uses to which Compressed Air Can be Put.—It is almost impossible to give anything like a complete list of the uses to which compressed air is put, but the following notes will help to convey some idea of the immense width of its application:

Power Transmission Proper.—In this is included all cases where the power is developed in one place, and is transmitted to a more or less distant point to be made use of in a motor for driving machinery. Among these may be mentioned motors for driving the machines used for charging gas retorts and for discharging coke ovens. In engineering shops many tools and appliances are used in this way, such as hoists, cranes, portable tools for riveting, both direct-pressure and impact tools, drilling, chipping, reaming, caulking, pneumatic hammers, portable jacks, and many other lesser uses.

Under this head also comes the establishment of general power transmission installations like those in Paris and Birmingham, where the power is sent from a central station to all parts of a district, to be used for any purpose for which compressed air may be suitable.

Power transmission in coal and metalliferous mines is one of the most important fields of usefulness for compressed air, and it is not too much to say that it is its use in this direction that has done as much as anything else to bring compressed air into its present general use. In mines compressed air is used for drilling, channeling, and rock and coal cutting generally, as well as for hauling and pumping.

Pumping.—Without being transmitted to a great distance, compressed air may and frequently is used for pumping, either by driving direct-acting pumps in the same way as steam, by the direct action obtained in the air-lift system of pumping, or by the use of air-displacement pumps. Very often the pump is placed immediately at the top of the shaft from which the water is to be pumped.

Railway Brakes.—Many thousands of brakes are now worked either by air compressed to a pressure above the atmosphere, or by air at atmospheric pressure working on pistons which have been relieved from the atmospheric pressure on the opposite sides or vacuum brakes.

Supplying Pressure to Workings.—In some engineering works at the present day it is found advisable, and indeed necessary, to have the work carried on in an atmosphere of compressed air, either to prevent the inrush of water or a fall of the material which is being worked. Examples of these uses are to be found in such cases as the Blackwall Tunnel, where the work was carried on through soft earth under the bed of the Thames, and the work was carried on between an air-tight shield and the face of the tunnel. It is also used in submarine works, in diving-bells, and for sinking foundations in caissons.

Other Uses of Compressed Air.—A few of the principal further uses to which compressed air is put are accumulators, the Bessemer process of steel production, diving dresses, chemical processes, bell ringing and organ blowing, sand-blast apparatus, street railway cars, cleaning carpets, sheep shearing, operating clocks, blast for furnaces, refrigerating machines, Shone sewage ejector, dynamite guns, filtering water and displacing oil, steering gear on ships, moulding machines in foundries, painting and whitewashing, and many other minor uses.

It will be seen that compressed air is of almost universal application.

Besides possessing the advantages which have been mentioned, compressed air is clean, easy to manipulate, and fairly economical for transmission purposes.

The Question of Economy.—Regarding the question of economy very much has been said and written, but apparently many of the writers on the subject have devoted most of their energies to discussing in all its minute details the question of the economical *compression* of air, and have left efficiency of the mains and motors to take care of themselves.

Compressed air carries along with it, in addition to its possibilities of economical working, several collateral advantages which cannot be taken into account and represented by numerical results, but which none the less represent definite gains in economy. Some of these have already been mentioned.

In the first place, it may safely be said that all parts of a power transmission installation should be made as efficient as possible, taking into consideration both the percentage of the power yielded for the power expended at the compressor, and at the same time taking into account not only this power efficiency, but also the cost at which it is arrived at and the cost at which the plant is maintained.

When a power transmission installation is put down a prime mover of some kind drives the compressor at one end at a certain cost, initial and for maintenance; and the air motor yields a certain percentage of the power put into the compressor at the far end of the line of mains. Although each part of the system should be as efficient as it is possible to make it, the fact must not be lost sight of that it is useless to strive after extraordinary degrees of efficiency when this is attained by an exorbitant expenditure in first cost or in maintenance. Where power is cheap and plentiful, as where there is an abundance of water-power available, there is no need to make use of the most expensive types of compressors in order to effect a comparatively small saving in the power transmitted. Any gain in economy, which is probably not desired by the owner of the works, will be swallowed up in interest on the greater first cost. On the other hand, where there is no natural supply of water, and transport renders fuel rare and costly, it will probably pay to put down a compressor of the very best kind, and the reduced fuel consumption may be expected to pay for the initial first cost. Also where the total power dealt with is large, it will pay better to use a high-class compressor than in small installations, where any gain in economy would only be represented by a very small sum of money. There are many cases where the cost of the compressed air installation is of small importance as compared with the gain in other directions. For instance, where a tunnel is being driven through a soft river bed, as was the case with the Vyrnwy water pipe for the Liverpool water supply, the cost of supplying the compressed air was of little importance as compared with the immunity from danger to the lives of the men employed on the work and the safety of the works themselves. If there had been a failure in the maintenance of the air supply at the working face, especially at high tide, when the pressure of the top of the tunnel was greatest, it is very likely that the face of the tunnel where the men were working would have fallen in, with a result which would have cost thousands of pounds to repair and some lives would undoubtedly have been lost. So that in this case it was of the utmost importance to maintain the air pressure at any cost, and for the purpose strength, durability, and good workmanship count for more than clearance and valve refinements, though there is no reason why these two should not go hand in hand.

On the other hand, there are many instances where the improvements in the economical working of compressors, and still more of the motors used, have made it possible to use compressed air, when, a few years ago, it was found to pay better to use hand labor. In one instance of this kind, where air motors were used for actuating a certain class of machinery for a time, it was found that the use of compressed air was more costly than doing the work in the ordinary way by hand labor, so that it was considered wise to discontinue the use of air for a time; but more recent improvements and developments in the economical working of the compressors and motors have made it possible to return to the use of compressed air with a very clear gain in economy.

It may be said without the fear of con-

tradiction that in the majority of cases, when a man thinks of spending money on a compressed air installation he is induced to do so not only because he thinks he can save so many pounds a year by so doing, but because he will be able to carry out some process more quickly and more perfectly than by the older methods. We are told that there are some 30,000 Westinghouse brakes at work on the railways of this country and in America. The Westinghouse air pump or compressor is one of the most wasteful which can be conceived as compared with the larger compressors, but there is no question about the desirability of its use in this direction. The advantages possessed by the Westinghouse air brake for convenience and certainty of action far outweigh any disadvantages which may be possessed by the compressors when regarded from a strictly economical point of view.

At the same time any waste of power means waste of money, and unless there are very valid reasons for this waste it should be avoided as far as possible. Every part of a compressed air system must be as economical in its working as it can be conveniently made without sacrificing other and more important advantages, and generally speaking the larger the installation the more important it is to have economical machinery.

The first part of an air installation is the prime mover which drives the compressor. Of recent years great improvements have been made in these. The most usual form of motor is a steam engine, and this should be of the most economical type that can be obtained at a reasonable price. Most of the larger sizes of compressors are now provided with Corliss valves and gear on their steam cylinders, and it must not be forgotten than a gain of 5 per cent. in economy in the steam engine is also a gain of 5 per cent. all through the system.

A great deal of attention has been and is now being paid to the question of economical compression. Better valves, less clearance, quicker speeds, and the introduction of stage compression have all done much to improve the general efficiency of air compressors. Every attention ought to be paid to the details of design so as to reduce the friction of the mechanism as far as possible and give a high mechanical efficiency. Piston-rod packings and piston rings are often causes of losses which, unfortunately, are not easily appreciated and located. The piston of an air compressor has not the same advantages as the piston of a steam engine, there being no condensed steam to act as a lubricant, and there is often a considerable amount of air leaking past the piston, and this leakage is difficult to detect.

The compressors of the present day, as made by the best firms, are fairly economical in their working, and there is not too much room for further improvement in this direction. But very much more attention has been given to improving compressors than to other parts of compressed air systems—if the details of many types of pneumatic machinery are excepted. Where motors are used for driving machinery by compressed air there is room for improvement in the greater use of expansive working, in the improvement in mechanical efficiency, and in the more general adoption of reheating the air before it is allowed to enter the motor.

While much attention has been paid to improvements in the design of compressors, not only have motors had to take a second place to compressors, but the mains also have not received the attention they deserve. It is no use to strive after a 5 per cent. gain in efficiency of compression at the cost of £50 and then to allow a 10 per cent. leakage of the air after it has left the compressor, especially when a little care in putting the joints together and a little more care in selecting the most suitable kind of packing would have saved the loss, at little or no cost. Too small a diameter for the air which has to be transmitted, too sharp bends, too many corners, all these interfere with the efficient working of the pipes. People who use compressed air are too apt to think that if they have a good compressor at one end and a good motor at the other any kind of a pipe will do so long as it serves to carry the air from the compressor to the motor. There is room for new designs of air pipe joints, which shall be air-tight, cheap, easy to make, and at the same time offer little resistance to the passage of the air.

Objections to the Use of Compressed Air.—One very potent cause which has

interfered with the adoption of compressed air in many cases has been the extraordinary prejudice against its use on the ground that the accumulation of ice in the mains and in the passages of the motors prevents the proper working of these parts. It cannot be denied that ice does very often collect in the pipes and ports, but one has only to look at the hundreds of successful installations of compressed air to be assured that the ice bogey is one that can easily be laid. Air always contains some percentage of water either in the form of visible moisture or invisible aqueous vapor, and the lowering of the temperature consequent on the adiabatic expansion of the air in the motors to a point below the freezing point of water, often causes the freezing of the moisture in the air, and this frozen moisture soon finds a resting place in the air passages. It accumulates against any projections or sharp bends in the pipe, and may in time cause the complete stoppage of the pipe. But by reheating the air before expansion, by making the inside surfaces of the pipes and passages smooth, and by avoiding sharp corners, it is perfectly possible and not difficult to prevent the closing up of the passages. These are important points to be attended to in the design of air motors and in the arrangement of piping, and the omission to attend to a single point may render impossible the working of an air motor. By proper attention to details of construction and design there is no fear of any trouble arising from an accumulation of ice in the pipes. It is a pity, however, that this question of ice has taken such a hold on some sections of the engineering public, who fail to see that compressed air could not have reached its present position among the means for transmitting power if this trouble had always been present.

Necessary Precautions.—The air which is taken into the air cylinder during the suction stroke should be drawn from a point outside the engine-house and where the air is cool and clean. Air drawn from the inside of the house is generally warm, and this makes the cooling arrangements less efficient, and moreover there is generally some dust in the air which tends to accumulate and clog the valves and passages.

When a complete compressed air installation has been put in, and the pipe connections made, it is well to close all the outlets from the pipes, work the compressor until the full pressure is reached at all points in the system, and then to allow the whole plant to stand, and meanwhile watch the pressure gauges. If there are any leakages in the pipes or connections they will very soon be shown by the falling of the pressure gauges. Besides a test of this kind on the first installation of the plant, it should be repeated at intervals to make sure that the compressor and pipes have retained their efficiency so far as air-tightness is concerned.

Compressed Air vs. Electricity.—Much has been said of late years as to the comparative suitability of compressed air and electricity as means for transmitting power, and much controversy has in consequence arisen. This controversy has generally been applied to the case of the transmission of power in mines. A thorough investigation of this point involves the consideration of a great many different points in relation to both compressed air and electricity. The advocates of each system can produce figures to show that the particular system advocated by them is the better. It is impossible to give all the arguments here, but it may be interesting to look at some of the chief considerations which may be expected to weigh for and against the use of compressed air.

In the first place, there are a number of qualities possessed by the one and not by the other. Compressed air has these advantages which electricity has not: The air sent out at the exhaust of the motors does not require to be got rid of as in the case of steam and water; but, on the other hand, when the motors are used in a mine or confined working of any kind, the exhaust air is a distinct gain, as it very largely helps in the ventilation of the space in which the work is being done. This is not a point which can be given a money value, but, all the same, it is a most important one, and is especially useful when air motors are used in the confined and often gassy workings of collieries. Another advantage contained in this exhaust air is to be found that the exhaust air cools as well as ventilates. Owing to the nature of a compressed fluid, when the pipes are full of compressed air, there is always a small reserve of power which can be

made use of at once without working the compressor, and this reserve of power is only a question of receiver capacity. Moreover, a compressor can be automatically controlled, so that its running is made to accommodate itself to the demand for air, and as soon as a sudden demand for a large supply of power is come upon the compressor it responds at once, and supplies the power as wanted. A third advantage inherent to compressed air is to be found in its elastic nature when used in quickly moving motors. Nothing but an elastic fluid could be made to work rock drills and pneumatic tools in the same satisfactory way, and it is equally applicable for use in lifts and riveting machines, although in some few cases it is advisable to interpose an incompressible fluid like water or glycerine between the air and the piston which is being actuated, so as to obtain a steady, even motion.

None of these qualities are possessed by electricity, but it has its own, which give it an advantage for some purposes. It has no exhaust, and no possible freezing up of passages. It is especially applicable when any rotating machinery has to be driven. One of the greatest advantages which electricity possesses is that its leads and conductors are extremely flexible, and can be turned in any direction without the trouble of making fresh joints.

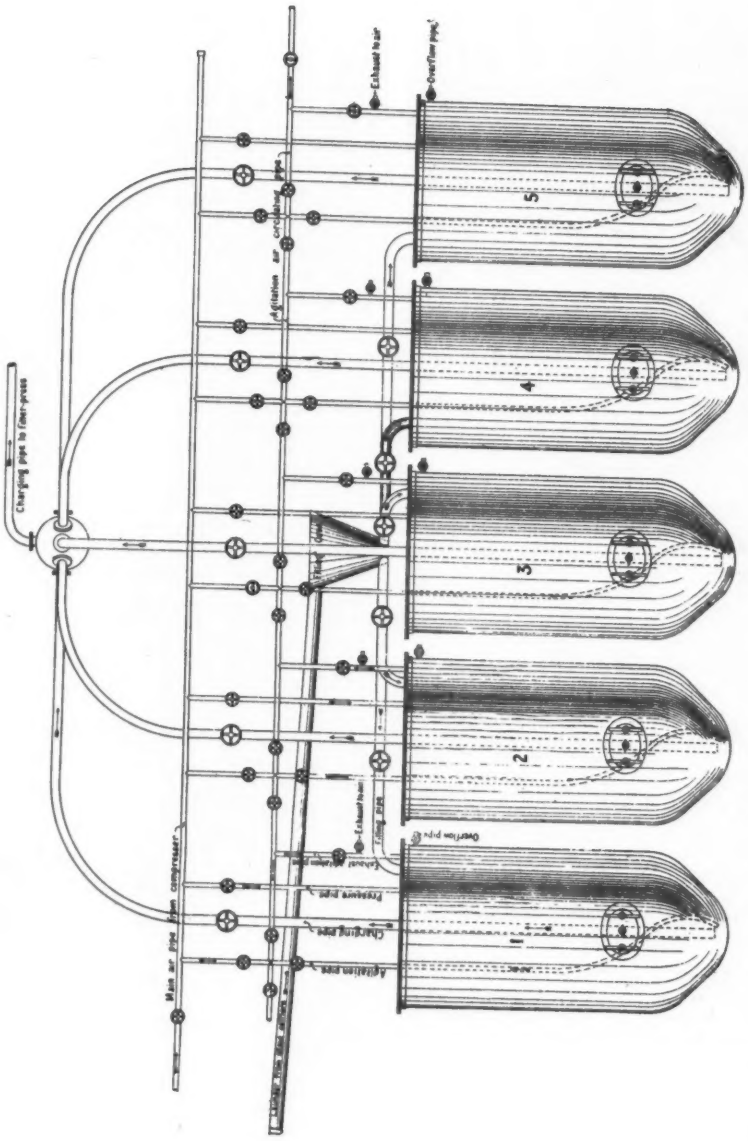
The disadvantages often urged against the use of compressed air for transmission purposes are its rather lower total efficiency as compared with electricity, the smaller flexibility of its pipes when compared with the electrical conductors, and the greater cost of these. On the other hand, besides the special advantages which have been mentioned in using compressed air there is no fear of a combustible and explosive atmosphere being ignited by sparking, as is the case where electric motors are used. This remark applies more especially to the cases where electricity is used for transmitting power to the workings of coal mines and where the air may be heavily charged with the inflammable fire damp. Various devices are employed to render the danger of such ignitions and explosions as remote as possible by inclosing the motors in air-tight casings or allowing them to work in an immediate atmosphere of carbon dioxide, and the increasing use of alternate current motors will largely conduce to the required end. But at the same time it must not be forgotten that where there is an electric current there must always be danger, because whenever the circuit is broken there is a spark of some kind produced, and where conductors are exposed to the rough conditions which are to be found in a coal mine there must always be a possibility of sparking, if not so much from the motors, but from accidental injuries happening to the conductors themselves.

It seems not altogether fair to compare compressed air and electricity as means for transmitting power on general lines, because the conditions which suit one will probably not be those which are most suitable for the other. There are some classes of machinery which are far better driven by compressed air than by electric motors, and there are cases where it is undoubtedly better to employ electricity. The mere fact that the use of electricity for power transmission is making such large strides and at the same time the use of compressed air has not received a check, but is rapidly widening year by year, only goes to show that there is plenty of room for both, each in its own particular sphere. The only thing about which there is any difficulty is in deciding which is the more suitable in a particular instance which admits of the employment of either one or the other.

Cyanidation at the Kalgurli Mine, Kalgoorlie.*

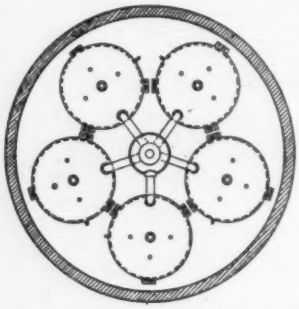
Air-lifts.—Air-lifts are sometimes alluded to in technical works as air-lift pumps, but while they do the work of pumps, they are not pumps, because they have no working parts, and for all practical purposes no wearing parts either.

* Abstract of paper by Mr. Edwin O. Watt in the Transactions of the Australasian Institute of Mining Engineers, as published by the *Engineering and Mining Journal*.

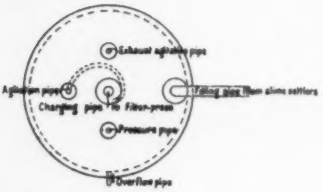


PNEUMATIC AGITATION AND FILTER-PRESS PRESSURE TANKS.

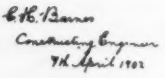
Air-lifts have been working under various conditions on the Kalgurli and Hainault mines, Kalgoorlie, W. Australia, for about twelve months. At present there are on the Kalgurli mine, in addition to the miniature lifts attached to the sand-vats, which are very small and inexpensive to work, two 8-inch and one 6-inch lifts in constant work, and on the Hainault mine one 6-inch lift taking away the products



Suggested Arrangement of Five Tanks.—



— Plan of Top of Tank.—



from a 10-stamp battery, but now being used only when the sand-pump is under repair. Nearly all the ore reduction works on the field are using one or more of them.

Amongst metallurgists and authorities on the field it is pretty unanimously acknowledged that, although they possess many advantages over a pump, they have proved rather expensive to work. Their efficiency on the actual steam power generated at the boilers is small; certainly not greater than has been estimated by Mr. Archibald, who introduced them into the district.

Pneumatic Agitators.—On the Kalgoorlie field the usual practice for the treatment of auriferous slime is to stir it with cyanide or bromo-cyanide solutions in steel vats with mechanical agitators for a period of from sixteen to twenty-four hours, afterwards charging it into pressure-tanks and thence to filter-presses. On the larger mines there are two exceptions to this rule, viz., on the Golden Horseshoe mine, where the slime is pumped direct into filter-presses, and cyanide solutions are afterwards pumped through at high pressure, and on the Kalgurli mine, where the slime is agitated by compressed air for three hours. It is with the latter process I wish to deal. The advisability of introducing oxygen in some form to the solutions during cyanidation is generally recognized by all metallurgists and cyaniders, and many experiments have been made of late years with the object of obtaining a cheap and reliable method of accomplishing this end. About twelve months ago experiments were started on the Kalgurli mine with the object of determining whether or not the pressure-tanks for the charging of the filter-presses could not also be utilized with advantage as pneumatic agitators. It had been previously noted that when slime was allowed to stand in the pressure-tank and compressed air was allowed to flow through the pulp to prevent its settling, a higher percentage of gold was extracted from the slime thus treated than if it were allowed to pass directly through from the mechanical agitators to the filter-presses. Slime pulp, previously untreated by cyanide, was then allowed to run into the pressure-tanks, where cyanide solution was added, and the whole pulp gently agitated by a stream of air for five hours. Some idea of the amount of air being used for this purpose may be formed when I say that it was about as much as would be blown from a good blacksmith's bellows. It was found that after five hours' treatment in this way the extraction of the gold contents was about 5 per cent. higher than when the slime was agitated by mechanical stirring for twenty-four hours, and that the cyanide solution came away 35 per cent.

richer in available cyanide than was the case after stirring. The time of agitation was then reduced to three hours, and an equally good gold extraction was obtained with a somewhat smaller consumption of cyanide. After two hours' agitation the gold extraction was not so good, but further experiments showed that an equally good result could be obtained in two hours when a larger volume of air was allowed to pass through the slime. A sample of concentrated sand was then treated in the same way. Before treatment 87 per cent. of this sample remained on a screen of 110 holes to the linear inch, and the gold contents were equal to 4 oz. 17 dwt. per ton. After three hours' treatment only 34.7 per cent. of the sample remained on the same screen, and the residues assayed under 3 dwt. per ton, thus showing that in three hours 32.3 per cent. of the sand had been reduced to slime, and a gold extraction equal to nearly 97 per cent. had been obtained. The exhaust air from the treatment of this sample came away warm in consequence of the friction generated by the sand particles grinding against each other. Subsequent grading analysis showed that this grinding action was always very marked when the pulp contained a large proportion of sand, but that, when fine separated slime was under treatment, there was only a slight diminution in the size of the particles, and under these circumstances the air came away cool. All these experiments were made on roasted sulpho-telluride ore. Experiments made with unroasted sulpho-telluride ore and potassium cyanide solutions did not give an extraction equal in any case to 60 per cent. of the gold contents. The results, however, proved so satisfactory that it was decided to continue to work the process. The exhausting air smelt so strongly of cyanogen that it was realized that a still greater saving of cyanide might be effected by passing the air through a series of pressure-tanks, instead of allowing it to exhaust direct through the atmosphere. On the treatment works there were only two pressure-tanks, and it was decided to install a set of five, using the same stream of air for the series. Some alterations were made in the design of the pressure-tanks, and the necessary pipes were attached to convey the air in a continuous stream through the pulp in each tank. The diagram on page 2595 shows the arrangement by which the combined pneumatic agitators and filter-press pressure-tanks are being worked at present on the Kalgurli mine. For the sake of clearness of illustration the set is shown in a straight line, but they are really being worked in a circular pit. Each agitator is 6 feet 6 inches in diameter and 13 feet 6 inches deep, and is usually charged with about 6 tons of slime in a cyanide solution of 0.10 per cent. of available potassium cyanide. After agitating for three hours the circulating air is shut off and the high pressure air is turned on to the top of the pulp. This drives the slime up the filter-press charging pipe into filter-presses, where, as previously explained, the auriferous cyanide solutions are recovered from the pulp. After discharging the slime from the agitators the tank remains full of compressed air at a pressure of about 30 lbs. per square inch. Instead of being allowed to blow into the atmosphere, as is usual under these circumstances, the air is used for discharging another agitator, or is allowed to circulate for agitation until it falls below the pressure required for that purpose. The air pressure required to agitate one agitator is about 3¼ lbs. per square inch, and for five agitators about 22 lbs., but this pressure varies slightly, according to the consistency of the pulp.

For charging filter-presses it is not convenient to work with an air pressure much under 30 lbs. per square inch, for, although it was found that a pressure of 10 lbs. would charge a 5-ton filter-press full, it took nearly an hour to do it, whereas a pressure of 30 lbs. per square inch will charge a 5-ton press in ten minutes. An experiment made with the present set of five pneumatic agitators may prove of interest to metallurgists. The agitators were charged with approximately 6 tons of ordinary slime in a solution of 0.10 per cent. of available potassium cyanide, and the usual stream of air was passed through for three hours. A sample of the solution was then taken from each agitator. No. 1 agitator, which first received the air, indicated .060 per cent.; No. 2, .100 per cent.; No. 3, .115 per cent.; No. 4, .115 per cent., and No. 5, from which the air

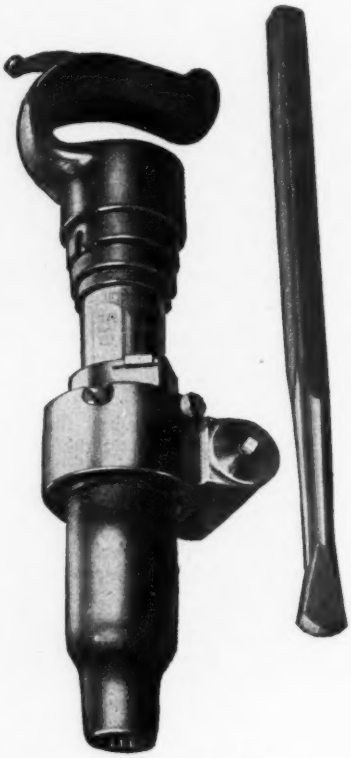
exhausted into the atmosphere, .060 per cent. of available potassium cyanide.

This experiment showed that in two of the series there was an actual increase in the amount of cyanogen in the solution, due to the volatile cyanogen passing over from the preceding agitators. The results of this experiment have been confirmed by other tests made on the Kalgurli mine and by laboratory tests made on other mines on the fields. When the Kalgurli mine agitated the slimes by mechanical stirrers for twenty-four hours it cost about 2¼ lbs. of potassium cyanide per ton to obtain a good extraction. With the present pneumatic agitators the consumption of potassium cyanide has fallen to about 1 lb. per ton, and the extractions are better.

The composition of the ore is practically the same, and the consumption of potassium cyanide on the separated sands has not varied. While I am of the opinion that the introduction of compressed air to the pulp in this way is beneficial in consequence of the fact that it oxidizes the cyanide solutions, I think that the beneficial action is more largely due to mechanical than to chemical causes, as instanced by the great attrition that takes place by the ore particles rubbing against each other, especially when these particles are not already in a very fine state of division. By reference to the diagram it will be seen that the agitation pipe is peculiarly bent, so as to give a violent rotary movement to the pulp. This, combined with the action caused by the surging of the air through the material, causes the particles to rub heavily against each other; the larger particles are thus worn away and the gold is cleaned and burnished, and thus rendered readily amenable to dissolution in cyanide solutions. This process of agitation has now been at work in the Kalgurli mine for ten months, and has been subjected to severe tests and has not failed. Its originality consists only in the method by which the air is admitted and used. The number of pipes and valves over the agitators appears at first glance somewhat complicated, but in actual practice it has not been found to be so, and the management have not experienced any difficulty in getting the attendants to understand the arrangements after a few minutes' explanation. No time has been lost by any fault of the arrangement, and no part of the plant has shown any perceptible wear.

New Pneumatic Devices.

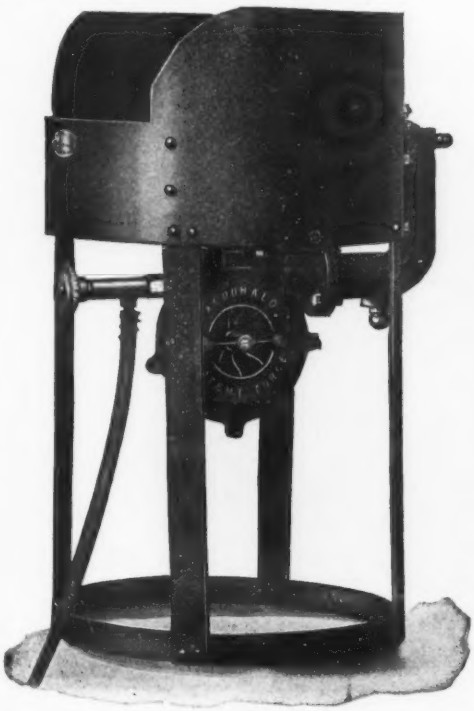
With the rapid growth of the compressed air appliances, commonly known as pneumatic tools, the various manufacturers of these tools are constantly



CHICAGO PLUG DRILL.

developing new or improved types and enlarging the general scope of the old ones. The Chicago Pneumatic Tool Company, of Chicago, has recently placed three devices on the market, a description of each of which may be interesting to those who are keeping in touch with the development of this branch of compressed air machinery. The Chicago

plug drill, as shown in the accompanying illustration, consists of an arrangement whereby a regular Boyer hammer is equipped with a drill and a rotating device. In construction it is simple. It consumes 20 cubic feet of free air per minute at 80 pounds pressure and, it is claimed, will drill a hole 5/8 of an inch in diameter by 3 inches deep in any kind of stone. It is used in all classes of plug and feather work and is said to be a practical machine for either top or side line work. Its weight, 18 pounds complete, makes it necessary for the operator to use only one hand.



CHICAGO AIR FORGE.

Another new comer is the Chicago air forge, which differs from others manufactured by that company in that it is an air blast forge for coal or coke, instead of using oil as fuel. The hose connection through which the air enters the forge is a ¼-inch standard pipe connection. The air, passing through a 1-16-inch needle valve jet, forces the fan to revolve rapidly and as the fan is open to the outer air, the blast of free air is continually blown upon the fire. It operates with an air pressure of from 60 to 100 pounds, and consumes approximately from 5 to 7 cubic feet of free air per minute. It is 3 feet high over all, and the pan or fire box is 20 inches in diameter by 10 inches deep. The forge weighs 114 pounds complete.

CHICAGO SAND RAMMER.

Another new device is the Chicago sand rammer, which is shown in one of the accompanying illustrations. The chief advantages claimed for it are its light weight, 17 pounds, and the fact that this machine can be operated by a man standing up, thereby eliminating the

necessity of continually bending over. It has a piston 1 1-16 inches in diameter and 7-inch stroke. It uses 30 cubic feet of free air per minute, and is claimed to give 500 blows in that space of time.

Portable Pneumatic Cranes.

No modern railway shop or terminal station is complete these days without a compressor plant. The great increase in the number of labor saving devices operated by compressed air has made this form of power transmission one of considerable importance to establishments of this nature. Particularly is it valuable where there is much loading and unloading to be done, and where considerable material of weight must be handled from any point within a considerable radius. The pneumatic cranes, particularly the portable ones, figure prominently under such conditions. Through the courtesy of the Garry Iron and Steel Company, of Cleveland, Ohio, we are enabled to publish illustrations of several of this company's pneumatic cranes which are now in active use. A description of a revolving crane manufactured by this company was published in the June issue of COMPRESSED AIR.

The smaller crane, shown in Figure 1, can be operated by either air or steam, and is mounted on a flat car, has a capacity of 1,000 lbs., a reach of 7 feet, and a lift of 12 feet 6 inches. This crane can also be mounted on a hand truck for convenience in moving it about in the storeroom or warehouse. On a separate platform, Figure 2 shows a crane of larger capacity, 4,000 pounds, used at the Collinwood shops of the Lake Shore & Michigan Southern Railway. This particular one is mounted on a hand truck, but, like the other, it can be placed on a standard car. This form of crane is mounted on a turn table.

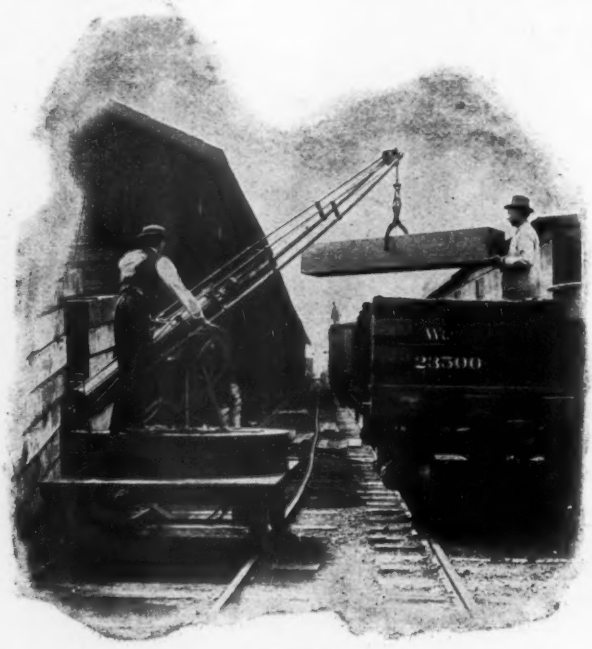


FIGURE 1.

The air cylinder which operates the hoist sets on an incline and is securely

fastened to the turn table as well as to the boom. The operating valve for this cylinder is of special design. It is so arranged that the volume of air is exhausted from one end of the cylinder to the other, or, in other words, when lifting the load the air, being at the front side of the piston, is exhausted through the valve to the other side of the piston, and the same volume of air is used for pressure behind the piston to lower the hook. The body of the valve is heavy cast iron, while the valve proper is of brass, tapered and ground to fit, and held in position by a Helican spring.

The boom is composed of heavy channels stiffened by top truss rods. The hoisting cable is usually made for a 12 feet 6 inches lift. The top of the turn table is one casting, to which is attached the operating valve, and also has a lug projecting downward, which engages with the buffer stop on the turn table base. The turn table carries the buffer stop, which consists of special castings, rigidly connected with the base, arranged with a buffer compression spring to lessen the work due to the inertia of the crane and load when completing its revolutions. To the top of the turn table is attached a pinion, securely bolted to it and passing over the pivot, which is secured to the turn table base. The air applied passes through pipes in this pivot, the connections from the pivot pipes being of hose in connection with a Moran flexible joint, thus permitting the operator to stand on the top of the turn table and govern all movements of the crane without changing his position.

FIGURE 2.

The cylinders for revolving the crane are attached to the turn table base back of the cylinder head, and held to the cylinder by guys is the moving rack attached to the piston rod, the top of the rack being additionally separated by a rack guide, which in turn is bolted to the crane base. This rack engages with the pinion which is bolted to the top turn table, and, by admitting air to the rack cylinders, the

turn table top is revolved in one direction. Naturally the stop comes in contact with the buffer on the turn table base, which occurs just before the piston has reached the end of its stroke. By admitting air to the opposite end of the cylinder the movement of the crane is reversed. In the crane already described, the hoisting cylinder is 21 inches in diameter and the racking cylinders 10 inches in diameter.

Either air or steam can be used for hoisting the load, revolving the crane and working the brake, and in special cases can be used for driving the crane and car along the track. The crane does not carry a storage reservoir, but can be connected either with an air line in the yard, or with a crane pipe line on the locomotive tender. These cranes are designed for an air pressure of 80 pounds per square inch.

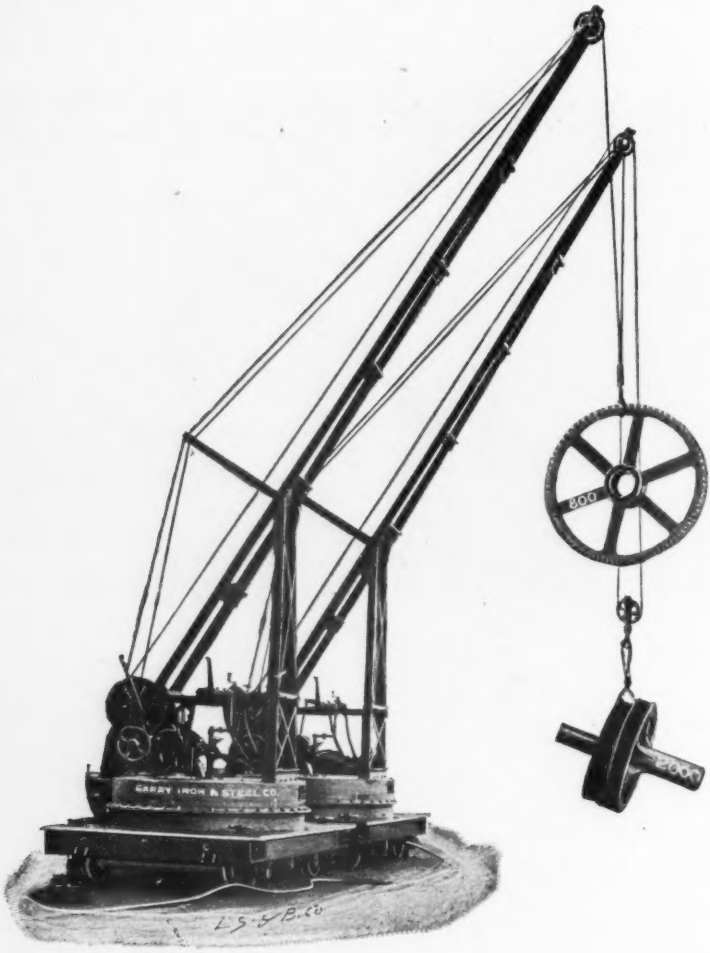


FIGURE 3.

More elaborate still is the pneumatic

crane shown in Figure 3, which has a reach of 12 feet with a height of boom suitable for a hook lift of 25 feet above the top of the rail or with sufficient cable to give a hook lift of 100 feet for use in building and excavating. The load is hoisted by a pneumatic motor, geared to a drill, thus maintaining the hook lift by the length of a cable. This crane is also revolved by pneumatic power.

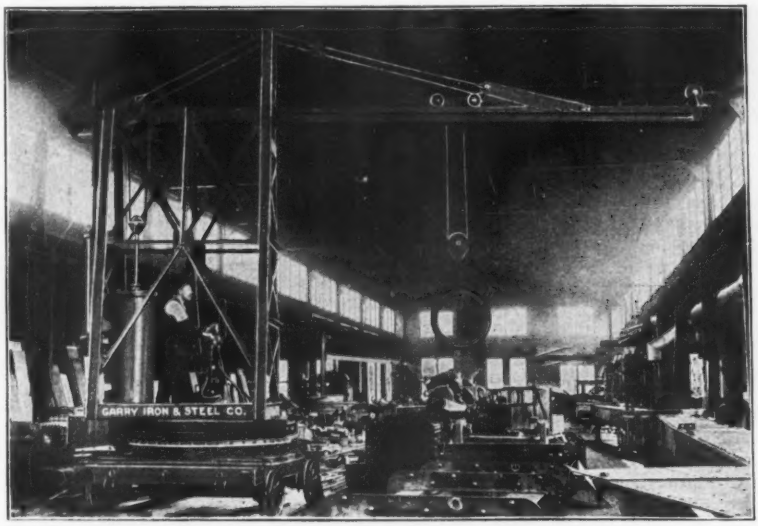


FIGURE 4.

Of a different type is the crane shown in Figure 4, which is mounted on turn table and car, and is for use in shops loading and unloading material where a variable reach is necessary. The crane is revolved, the load hoisted, and the trolley run in and out by air pressure.

Electrically Driven Compressors.

While compressed air and electricity are frequently considered as rival forces, yet, as a matter of fact, they are found more and more frequently together as allies rather than as rivals. The electrical driven compressor is by no means new and the field for this form of compressor seems to be constantly growing. The Christensen Engineering Company is now manufacturing a line of these motor driven compressors, ranging in capacity from 4 to 1,000 cubic feet of free air per minute. The smaller sizes are made for portable as well as stationary service.

In the Christensen machines the electric motor and the compressors have been designed to form a compact self contained unit. The air is compressed in the cylinder by a double acting piston, which is operated by means of a connecting rod and steel crank shaft. The latter is mounted in bearings located within the frame of the machine. This shaft carries on the motor end a helican gear, which is driven by a pinion on the armature shaft of the motor. The gear and pinion are of the helican herring bone type with teeth cut by special machinery. It is claimed for them that they are almost noiseless.

The gear and the crank chamber are connected to form an enclosure, which is partly filled with oil, with which all the working parts, including the air cylinder, are automatically lubricated. The gear and the pinion operate continuously in the oil bath. The machine, it is said, will remain lubricated as long as the oil is kept up to the level determined by the filling block on the side of the crank chamber. Either an alternating or continuous current

may be used in the electric motor. The lower frame of the motor is of cast iron and the entire machine is mounted on a cast iron base. The design of the motor in the compressor is such that, it is claimed, every part can be easily and quickly reached.

An automatic governor is designed to start and stop the motor compressor at the desired minimum and maximum pressure. This governor consists of an ordinary pressure gauge mechanism, with a special hand, which, upon coming in contact with the conducting stud at the position of minimum pressure, allows the current to flow through a magnet coil. This coil operates a plunger to which the contact pieces for the motor circuit are attached, thereby closing the circuit and starting the motor. As soon as the pressure reaches the desired maximum, the end strikes another stud and the current passes through a second solenoid magnet, thereby pulling the plunger in another direction and opening the motor circuit.

For portable service the Christensen Company mounts one of its electric driven compressors with automatic governor and an air receiver on a suitable hand truck, which can be moved wherever necessary. This portable outfit is useful wherever pneumatic tools or other compressed air appliances are used and an expensive system of piping is not desirable. In these cases the compressor is taken to the work instead of transmitting the compressed air from a stationary compressor at a distance. These compressors were sometimes mounted on a wagon and transported by horse for use in drilling and bonding rails in electric railway or other work where electric power can be obtained. It is only necessary to make a connection to a trolley wire by means of a hook or pole for the purpose of obtaining power for the motor. For similar kinds of work the compressor is sometimes mounted on a car which runs on rails.

Electro-Pneumatic Inter-Locking at Solvay, N. Y.

The New York Central & Hudson River Railroad has recently installed and put in service an electro-pneumatic interlocking to protect the junction of the Auburn Branch and the West Shore connection with the main line at Solvay, N. Y. The connecting track between the West Shore and the New York Central being 2,200 feet long two towers have been put in and one power-house is used to furnish compressed air for both interlocking plants. The interlocking machine in tower No. 2 controls the switches and signals of the New York Central plant and is provided with 30 working levers and five spare spaces. Fourteen levers are used to control 29 switches and four pairs of movable point frogs and 16 levers to work 37 signals. Tower No. 1 at the junction of the connecting track with the West Shore main line has an 11-lever machine with six working levers and five spare spaces. The small number of levers required for the functions controlled is one of the chief advantages of the electro-pneumatic machine. With a mechanical machine a lever is usually required for each switch or signal operated in order not to put too great a load on the connections, but with the electro-pneumatic as many switches can be worked by a lever as will permit of the proper routes being set and the signal levers, in addition to selecting between the arms of a route signal, can be used to control the arms of a signal reading in the opposite direction. When turned to the right a lever may be made to work one signal and another when turned to the left.

There is no direct interlocking between the machines in the two towers, but protection for traffic over the single-track connection from the New York Central main line track No. 4 to the West Shore road is secured by means of the Union lock and block system, which is interworked with the electro-pneumatic machines and effectively prevents the display of a clear signal from one tower over this route should permission have been granted from this tower for the clearing of signals at the other for this movement. The Union lock and block system also applies on the main line tracks 1, 2, 3 and 4 of the New York Central for the control of trains entering the block on either side of the towers. Track circuits are used to control all main line signals. The signals governing these protected tracks are semi-automatic and remain in the stop position whenever the track is occupied.

The apparatus used is the electro-pneumatic manufactured and installed by the Union Switch & Signal Company under the supervision of Mr. P. G. Ten Eyck, signal engineer of the railroad company. The power-house, which was furnished complete by the railroad, is located just east of tower No. 2 and contains a repair room in addition to the air compressing plant. Two sets of equipment are provided, so that if one should fail the other may be used to furnish the necessary power to run the plants. One set is operated by means of an electric current from the lighting plant of the city of Syracuse, and consists of a Western Electric 15-horse-power, 220-volt, 40-ampere, 60-cycle motor directly geared to an air compressor. To charge the storage batteries furnishing current for the electro-pneumatic machines, a Holtz-Cabot 1-horse-power motor dynamo is used which transforms the city voltage of 220 to 20 volts. Two sets of storage batteries with seven cells of 120 A. H. chloride accumulator type in each set are used, one set being charged while the other is discharging.

The equipment intended for use in case the city supply should fail consists of a Fairbanks-Morse 20-horse-power gas engine, which is belted to an air compressor made by the Rand Drill Company. Connected to the gas engine is a 110-volt dynamo, which, in case of emergency, is used to generate electricity for lighting the signals in addition to charging the storage batteries.

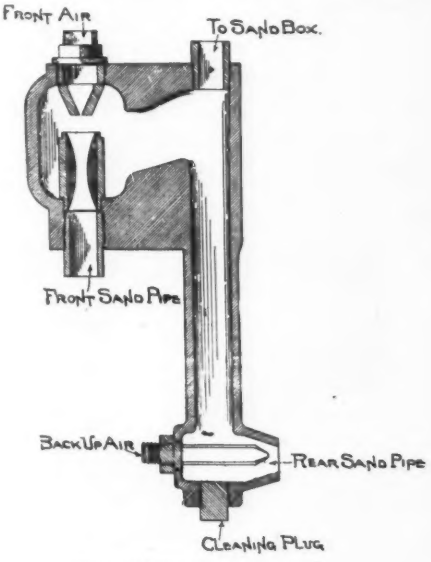
For cooling the compressed air a manifold condenser having 58 square feet and an intercooler with 200 square feet of surface have been provided. The running water used to cool the cylinder and air passing through the intercooler is stored in a 6 by 12 feet cooling tank and used over and over again. The air storage tank measures 5 by 10 feet.

The signal lamps are lighted by two 4-candle-power lamps, connected in parallel on a 110-volt circuit and placed in tandem in the center of the lens so that if one lamp goes out the other will furnish light. The main feed wires to the signals are run on poles and have waterproof insulation. The connection between the mains and the signal lamps is made by twin lead-covered wires run in an iron conduit.

The wires carrying the current to operate the switches and signals of the plant are in cables and as far as possible are run in trunking and buried in the ground. The electro-pneumatic magnets controlling switches have a resistance of 130 ohms and for signals 420 ohms. The relays for track circuits are the Union Company's universal type, with 5 ohms resistance. The signal poles are of iron, with the connections inside of the mast. The main posts of the bracket poles are of channel iron and lattice construction. Galvanized pipe has been used for all air supply, the mains being 2 inches and the branches ¾ inch and covered with wooden conduit.—*Railway Age.*

Pneumatic Track Sander.

J. H. Waters, assistant master mechanic of the Georgia Railroad, has invented a pneumatic track sander, which has been



PNEUMATIC TRACK SANDER.

since placed on the market, and is used, it is said, with considerable success by a number of railroads in the South.

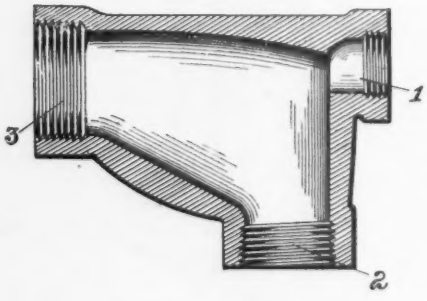
The accompanying illustration shows this double convertible sander, which is so

arranged that a gravity feed may be used in case of failure of the air system. There is a combination of two ejectors, one vertical, for forward sanding, the other horizontal, for backward sanding, both being fed from a single pipe to the sand box. The back-up ejector is separated from the other and dropped below the running board so that the air jet can be removed when necessary to clean it out without disconnecting the pipe.

The upper or forward ejector can be located at any point above the running board, preferably close to the sand box. The air jet to the latter is contained in the cleaning plug, and, it is claimed, is easily removed to clear any obstruction. The sand blast for forward sanding is all on a loose tube, which can be renewed at a small cost. It is claimed for this arrangement that it takes care of the ejector case entirely, so there is no wear on it. An ordinary wrench is all that is necessary to take care of the sander. It can be emptied through the forward pipe without allowing any of the refuse to get on the engine machinery.

A Pneumatic Siphon.

Among the recent inventions which have served to bring out the further use for compressed air in the foundry is that



PNEUMATIC SIPHON.

of Andrew J. Weekley, of East Pittsburg, Pa. He has patented a pneumatic siphon to remove the sand, filings and scales from difficult recesses and spaces within iron molds and the like. He claims to have perfected a siphon that will rapidly remove the refuse without clogging or otherwise obstructing the passage, and that while extremely simple, strong, durable and comparatively inexpensive to manufacture, it is highly efficient in its use.

Molders have experienced considerable trouble in removing the refuse matter from small recesses in the castings. The undesirable material is generally loosened by means of a rod and is then ready to be drawn through the suction pipe. Mr. Weekley's invention regulates the passage of the compressed air which causes the suction. The accompanying cut, which shows a sectional view of the body of the siphon, illustrates the peculiar arrangement whereby Mr. Weekley claims to overcome any clogging or obstruction. He says that any lumps or other bodies of solid material will pass readily through it, since they are not required to make a turn in the chamber at direct right angles to the air inlet pipe.

In this illustration, 1 is the inlet or suction pipe which has its inner board downwardly deflected; 2 is the air inlet pipe, and 3 the discharge pipe.

Cleaning Air by Washing Instead of Filtering.

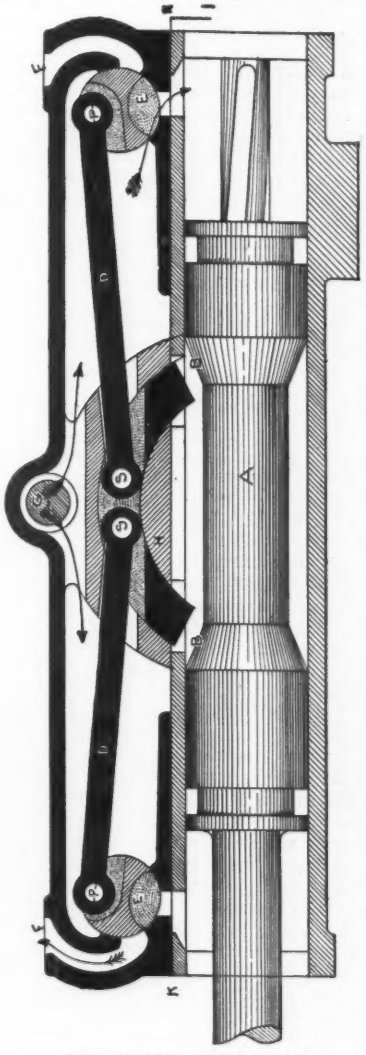
It has been demonstrated that much the larger share of trouble caused by imperfect contacts in switchboard connections in telephone exchanges can be prevented by proper ventilation of the operating rooms, and that implies thorough cleansing of the air entering them. Many experiments have been tried in the way of dry-cleaning by filtering through screens of wire and cheese-cloth or cotton-batting, but all such devices require frequent renewal, sometimes at considerable trouble and expense. By continued use any filter of this character must deteriorate and eventually become clogged, and in order to avoid the results of neglect it ought to be practically automatic. This point is essential in an air-cleaning system. In the case of one large telephone company very satisfactory results have been obtained by passing the air supply through a fine spray of water and afterward precipitating the moisture with the col-

lected impurities and discharging it into the sewer. The water, which is taken up at high velocity and held in mechanical suspension, is extracted by centrifugal force by passing it through a series of tubes in which spirals are so placed as to give the air a whirling motion, causing the suspended particles, which are heavier than the air, to be thrown outward and brought in contact with the tubes, from which they flow through perforations to a drip-pan below. The washing process imparts about 70 per cent. humidity at a temperature of 70 degrees Fahr. in the operating room. This is considered the most desirable for health and comfort and avoids the excessive dryness sometimes resulting from other systems of heating and ventilating. Moreover, in summer time, with the temperature outside at 80 degrees Fahr. and with the normal temperature of the city water, the air delivered to the rooms can be readily reduced to 70 degrees. This is a supplementary advantage which must appeal at once to sufferers from extreme summer temperatures everywhere, and with the growing knowledge that such an advantage is available will undoubtedly come the insistence that buildings should be kept cool in one season as well as warm in another.—*Cassier's Magazine* for September.

The Torpedo Baby Drill.

The Torpedo baby drill is the latest of that type of rock drill to make its appearance on the market. It is controlled by the Rix Compressed Air Drill Co., of San Francisco. It is similar to the North Star baby drill with the exception of the piston valve chest and cylinder, which are designed with the idea of accomplishing more work. By its construction it is claimed that this drill will give more than 100 blows per minute in excess of any other drill of that type. With its increased speed it is claimed that it will strike harder and that the repairs will be less. The new valve motion will run at full speed, it is said, on any stroke from 2 inches to the full stroke of 5 inches. Reference to the accompanying cut will make the construction and operation of this drill easily understood.

A is the piston which impinges on a circular rocker operating within the Torpedo valve chest which is bolted to the cylinder on the line *KK*. The circular rocker is held in position by the



THE TORPEDO BABY DRILL.

bronze guide *H*, which is removable. Attached to the rocker by the pins *SS* are two valve rods *DD* which are attached to the circular valves *EE* by the

pins *PP*. These circular valves *EE* are Corliss valves which fit within steel bushings. The inclined surfaces *BB* on the piston, coming in contact with the ends of the rocker, slide the rocker in its seat, and cause the valve to open and close. In this drill the ports are 7-16 of an inch wide by 1⅛ inches long, just about twice the opening used in the ordinary baby drill. The movement of the rocker is simple and always in the direction of the motion of the piston. The air is admitted into the valve chest at the opening *G*, and when the valve is open it passes through the ports, which are about half an inch deep, into the drill at either end. The exhaust is at the ports *F* and *F* on each end of the drill. The valve rods *D* are made of tool steel.

This valve system is the invention of Mr. A. D. Foote, superintendent of the North Star Mines, Grass Valley, Cal.

Miners' Phthisis.*

Applying the term miners' phthisis to the deeply pigmented and somewhat solid state of lung found in miners who during life have exhibited signs and symptoms of pulmonary disease of a more or less chronic character, Dr. Oliver said that, while the malady had generally been regarded as the result of breathing a dust-laden atmosphere, it was much less common now than fifty or sixty years ago. This circumstance he attributed to the improved system of ventilation of our coal-pits. Miners' phthisis as a morbid entity has been known since 1703, when Ramazzini drew attention to it. In 1860 Peacock proved microscopically and chemically the identity of the particles of dust found in the lungs with the dust of the atmosphere in which the patient had worked during life. There was sufficient evidence to show that pneumokoniosis was a dust disease and due to occupation, also that the phthisis bore a distinct relation to the form and character of the dust inhaled, for, as Hirt had shown, in each hundred workmen suffering from pulmonary consumption caused by dust, metallic dust was responsible for 28 per cent. of the cases, mineral dust for 25·2 per cent., animal dust for 20·8, and vegetable dust for 13·3 per cent.

There are two ways by which the pathology of miners' phthisis could be studied. (1) Pathological inquiry in man, and (2) physiological experimentation in animals.

The dust that is inhaled under ordinary circumstances gets caught on the nasal, pharyngeal and laryngeal mucous membranes. Should particles of dust reach the trachea and bronchi, they become entangled in the mucus secreted by the tubes, and are either wafted outwards by ciliary motion, or are coughed up. This barrier apparently becomes broken, for as life proceeds the lungs of all persons, of town dwellers especially, become more or less pigmented. Discoloration of the lung is quite consistent with health. There must be, therefore, something superadded to the pigmentation to cause the lungs to become pathological. When particles of dust reach the pulmonary alveoli Dr. Oliver showed that while the amount of local reaction was determined by the form and character of the dust particles, there were present in the alveoli large wandering cells which were distinctly phagocytic in their nature. By these cells particles of coal dust were swallowed and transported into the plasma spaces of the alveolar wall and into the lymphatics, by means of which they were carried to the bronchial glands. The pulmonary lymphatics run under the pleura, in the interlobular septa and on the walls of the blood-vessels and small bronchi.

Dr. Oliver exhibited drawings of microscopical sections of lung taken from a Transvaal gold miner, whom he had seen in consultation with Dr. Dodds, of Cramlington. In the lung, in addition to marked fibrosis, there can be seen large cells filled with black granules, some of which have wandered outside the alveoli. These cells disintegrate and liberate the black particles. Newly-formed fibrous tissue can be seen interpenetrating itself between these large cells. To Dr. Oliver pneumokoniosis is not a tuberculous disease. Tubercle is often met with in miners' phthisis, but when present it is an accidental and, therefore, a secondary infection.

Speaking of the causation and experimental production of anthracosis, Dr. Oliver eliminated the gases liberated by the coal, and those formed as a result of the explosives used in the mine, as playing any part in pneumokoniosis. Claisse and Joués' experiments upon animals that

*Synopsis of an address by Thomas Oliver, M. D., F. R. C. P., physician to the Royal Infirmary, Newcastle upon Tyne; introductory to a discussion at the Swansea meeting of the British Medical Association, July, 1903.

had inhaled the smoke from burning lamps were alluded to, in so far as confirming the previous statement, viz., that the lungs could become deeply pigmented and yet health be maintained and no pathological alteration occur in the lung tissue. Trotter, of Bedlington, looks upon anthracosis as an epiphenomenon in pulmonary disease, and attributes the fibrosis not so much to the coal itself as to the accompanying particles of stone from the sandstone strata and seggar clay, etc.

The most important point is how far miners' phthisis is or is not a tuberculous lesion. One of the strongest advocates of the tuberculosis theory of anthracosis is Dr. Tripier, of Lyons—to him tubercle is not a coincidence nor a secondary infection, but the principal cause of pneumokoniosis. Since Koch discovered the tubercle bacillus there has been little written upon the subject of miners' phthisis. One of Tripier's patients was a miner who had worked for fifteen years in the Mont Cenis and St. Gothard tunnels. The construction of both these tunnels was attended by a great loss of human and equine life. Many of the miners died from pulmonary disease and from anæmia due to ankylostomiasis. The tunnelling of the Simplon, which is going on at present, has been conducted with a remarkable freedom from tuberculous lung disease—a circumstance which is attributed by Dr. Volante, of Iselle, to the excellent system of ventilation that prevails. There is plenty of smoke in the tunnel and the air is fouled by the respiration from the men and horses, but as the perforation of the rock is accomplished by machine drills under hydraulic pressure, and water is automatically sprinkled on the debris at the time of the drilling, there is no dust, and to this circumstance is largely due the remarkable absence of lung disease among the miners.

After renewed allusion to the part played by phagocytes in conjunction with dust in causing pneumokoniosis, Dr. Oliver summarized his conclusions thus:

1. Miners' phthisis is not caused by the inhalation of any of the gases present in the mine.

2. In pneumokoniosis there may be not only excess of fibrous tissue, but even cavities and tubercle.

3. The disease is, however, non-tuberculous.

4. Accepting this view of the pathology of the disease, there is hope that by improved ventilation and by allaying the dust with water, miners' phthisis may still further be diminished.

Rock Drills.

It has been stated that the correct principle of successful rock drilling is to get a hole into the rock, of the right size, as rapidly as possible with the least hand labor, the amount of mechanical energy taking a secondary place.

There are two ways of drilling; one, the auger drill, which bores the rock; the other, the percussive drill, working by direct impact, that is, by striking repeatedly in the same spot, and by simply bruising or chipping away the rock. The Ingersoll-Sergeant people say that long and expensive experience has shown finally that a reciprocating, punching, or percussive drill is the best suited for drilling rock. The advantages of a power machine over hand labor in percussive drilling under most circumstances are obvious, and the essential features of a good rock drill are as follows:

First and foremost, the mechanical principle and construction must be perfect; there must be no hitches about it; it must always be ready to operate and be under the absolute control of the operator, so that a hard or light blow, either long or short, can be struck at his will.

It must be light, so as to be portable, easily erected and dismantled; compact, so that it can be used in restricted and out-of-the-way places; it must be made of exceptionally good materials, to insure durability of all its parts; it must not be complicated, and it must be made up of pieces so formed that they can be quickly removed, all being interchangeable; it must be so simple that its successful operation is readily mastered by the men at hand, and it must not have any parts which grit, exposure, or rough usage can seriously damage.—*Mines and Minerals.*

Pneumatic Ash-Handling Plant for the Chicago & Alton Ry.

At its yards in McKinley Park (formerly Brighton Park), Chicago, the Chicago & Alton Ry. has recently installed a plant for handling ashes dumped from locomotives which use the roundhouses at this point. The plant consists of pits in two tracks, with a loading track between; buckets running upon trucks in these pits, and a pneumatic crane spanning all three tracks. The arrangement is not entirely new, having been in use for some time by the Pennsylvania R. R.

Figure 1 is a view of one of the pits of the plant, with the buckets therein. Each bucket is carried upon a 4-wheel truck and sets in a rack attached to the truck. The trucks are run to position under the ash pans of the locomotives, and at convenient times are lifted by the pneumatic hoist and dumped into cars on the centre loading track. As the bucket is hoisted it is lifted off the truck, and when high enough to clear it is moved laterally to position over the cinder car, as shown in Figure 2. The bucket is dumped by hoisting it still further until arms attached to the interior of the two halves of the shells meet with a ring attached to the hoisting cylinder, which serves as a stop to trip the shells of the bucket. Figure 3 shows the bucket in the tripped position.

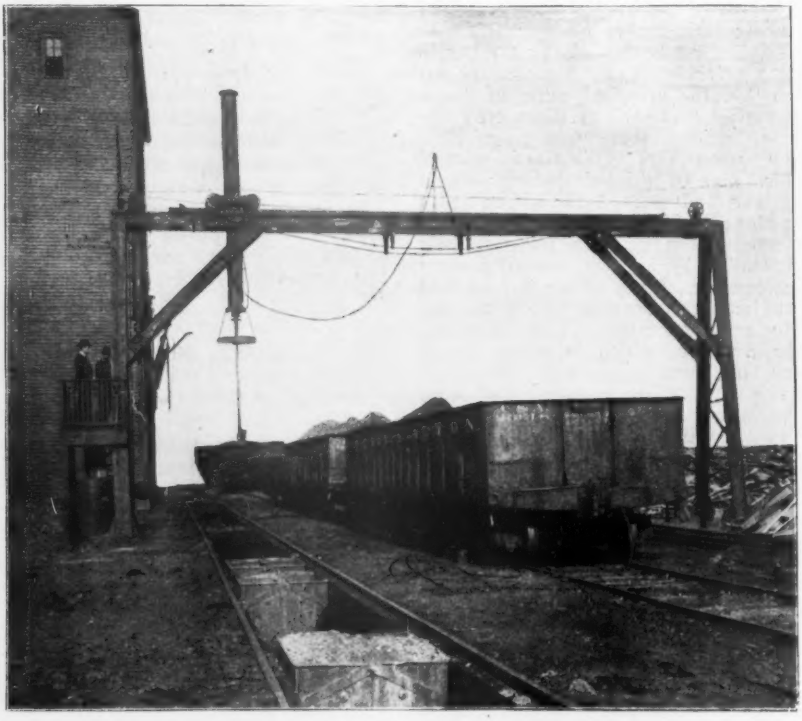


FIG. 1—PNEUMATIC ASH-HANDLING PLANT, CHICAGO & ALTON RY.

All of the movements necessary to the operation of the hoisting of the buckets and the lateral travel of the same are accomplished by means of compressed air apparatus. The main hoist is a simple cylinder with a piston lifting direct. The lateral travel of this hoist, to move the bucket to position over the cinder car, is accomplished by means of an air cylinder,

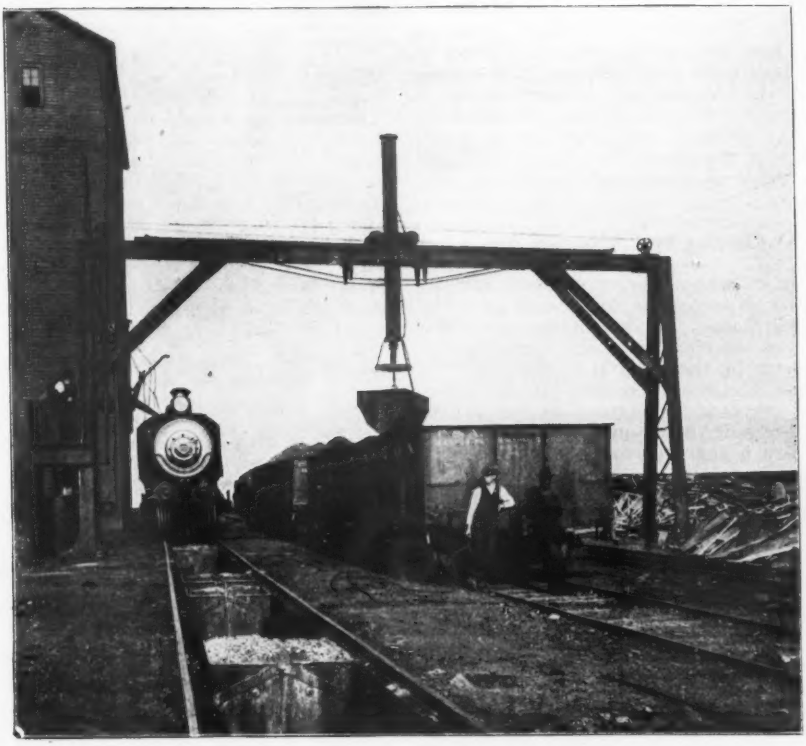


FIG. 2—PNEUMATIC ASH-HANDLING PLANT, CHICAGO & ALTON RY.

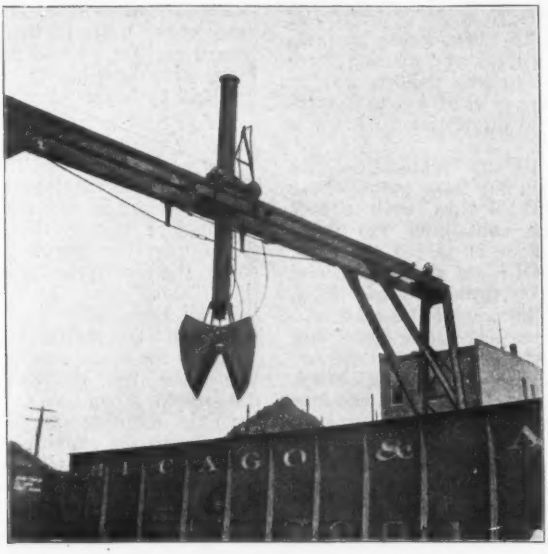


FIG. 3—DUMPING THE BUCKET.

wire rope and pulleys, the arrangement of which is quite clearly shown in the illustrations. At the left of the picture in Figures 1 and 2 may be seen the platform for the operator, who controls the movements of the plant by means of ordinary air cocks.—*Railway and Engineering Review.*

Cleaning by Compressed Air.

House cleaning by compressed air has proved as successful in England as in the United States. The patents for the methods of vacuum cleaning controlled in America by the General Compressed Air House Cleaning Company, of St. Louis, Mo., are used in England by the British Compressed Air Cleaning Company. This concern is reported to be operating with great success in England and in South Wales, and is said to be rapidly forming subsidiary patents through the Provinces. All the usual branches of house cleaning are cared for, and occasionally the English company departs from the beaten path and experiments in other lines. A description of such an experiment is reprinted from the Burton (England) *Mail* of August 6, 1893, as follows:

"An experiment is being tried at the extensive maltings of Messrs. L. and G. Meakin, Burton, which cannot fail to be watched with great interest by the brewers of Burton and the industries allied with the staple trade of the town. We refer to a system of 'kiln-pricking' by means of compressed air. To those whose business is connected with kilns and malting there is no need to relate the tedious way in which the kilns are pricked, but to the uninitiated it will be interesting to know a few details.

"Without use of any technicalities, we may say that a kiln is a large room, whose floor is composed of tiles, each a foot square, and each containing 720 small holes. On this floor is spread the malt. Fires are made in a room underneath, and the heat, rising up through these holes, accomplishes the kilning of the malt. In the course of the year these holes are bound to become clogged up by the minute particles of dust, inseparable from barley, as from everything else. So it becomes necessary for them to be cleaned out. In order to do this, perhaps 20 boys are turned into the kiln with prickers, which resemble nothing so much as a short stout needle fixed in a gimlet handle.

"The kiln we have in mind is one of 150 quarters capacity, and by extreme diligence the 20 lads might accomplish the "pricking" in a little under three weeks. Each hole has to be pricked separately, and it is quite likely that when the lads are working the pricker and about to clear the hole they will chip a portion of the tile, and if there are several bad chips in a tile a new one, costing about tenpence, is necessary. Such a system as this, at the best, is crude, but as it is the only system, maltsters have to do as well as they can and foot the bill.

"A short time ago Mr. Lewis Meakin was in London, and saw at work one of the British Compressed Air Cleaning Company's machines cleaning a club. Being struck with its simplicity and efficacy, and also the probability of superseding the present tiresome method of "kiln pricking" with advantage to all concerned, he arranged with Mr. F. L. Bronaugh, the managing director of the company, to bring the machine and other apparatus to Burton, to see if it would answer the purpose.

"It has proved of some use; indeed, the effect has been startling. There is really little to describe in the process, it is so remarkably simple. You observe in the yard of the malting a miniature furniture van, which is an engine. You hear the throb, throb, throb of the petrol-actuated machinery, and notice small hose-pipes going aloft to an upper story window. You trace these pipes to their end and see a huge cannister. From this emanate other diminutive hose-pipes; the ends of each are held by boys.

"You hear a tremendous hissing, as of escaping steam, but you see nothing, absolutely nothing, beyond the mere fact that these boys are moving the nozzles of the pipes backwards and forwards over each of the foot square tiles, across which a damp mop has previously been run to soften the dirt in the holes. "Where's the dirt?" you ask. That is blown clean through into the fire room below; anyway, it does not trouble the kiln any more.

"Now for a few comparative statements. Under the style which has obtained up to the present, a boy was 12 minutes, working hard, in cleaning one tile, with its 720 holes; with the compressed air he can do it in half a minute, with much less trouble to himself, and with much more cleanly effect.

"Under the old style the holes could not be thoroughly cleared, for there was bound to be some dust or dirt left clinging to the bottom edge of the holes. But with the force behind it of 140 lbs. pressure to the square inch, the accumulations of dirt are removed with a rapidity which is startling, and an effectiveness which is gratifying.

"It is computed that by this means a huge kiln, which it formerly took 20 boys three weeks to clean, can be cleansed by four or five boys in—at the most—a day and a half. Next, as to the cost! As this has only been tried as an experiment, Mr. Bronaugh cannot yet promise that it will be any less than under the other method. Certainly, he says, it will not be more, and very soon, when he has been able to make his calculations, he hopes to do the work at a cost which will be 25 per cent. less than the old style.

"This should insure the new method an appreciative reception in Burton, where there is considerable scope for the work of such a machine. Already, the engineers of many of the big breweries have seen the apparatus at work at Messrs. Meakin's maltings, and have expressed themselves as highly satisfied with it.

"We have said sufficient to show that the method under notice is immeasurably superior to the method which has been in vogue hitherto. The increased efficiency, a vast saving in time and substantial reduction in cost, is sure to bring the method into favor in Burton. Thanks must be accorded Mr. Meakin, who was so soon to recognize the possibility of its adaption to the purpose mentioned.

"The compressed air system was brought before the public for the purpose of cleaning carpets, draperies, chairs, walls, from dust without any of the usual tiresome preparation for 'spring cleaning' being made. The machine will gather up the dust from any material, and is in use at the Royal palaces. Mr. Bronaugh has received instructions to clean the large carpets at the offices of Bass, Ratcliff and Gretton, Ltd."

The Gas Turbine.

In connection with a discussion on the steam turbine at the Master Mechanics' Convention, at Saratoga, Prof. Hibbard, of Cornell University, announced that there were prospects of developments in the field of the gas turbine at the General Electric Company's works, Schenectady. A gentleman, who recently received an advanced degree at a Western university in virtue of a very thorough investigation on the subject of the gas turbine, is now in the employ of the General Electric Company, and the inference is that he will have at his disposal the extensive facilities of this company for conducting experiments that may eventually lead to a successful gas turbine. This gentleman is Mr. Sanford A. Moss, who has made a special study of the subject of gas turbines since 1898. He received the degree of Master of Science at the University of California, and has also studied at Cornell University, specializing upon the same subject —that of the gas turbine.

The great thermodynamic advantage of the steam turbine over the steam reciprocating engine is that there is no condensation and re-evaporation through contact with metal surfaces which are alternately heated and cooled. The only condensation in a steam turbine to amount to anything comes from the conversion of the energy of the steam into work. In the gas turbine there is, of course, no condensation to enter into the question, but there is an opportunity for another and more important gain through the abolition of the water jacket. It is a singular fact that the turbine is theoretically and probably practically capable of effecting a saving over the reciprocating engine, whether used with steam or with heated air, but because of entirely different reasons in each case.

It is well known that the efficiency of the gas engine depends mainly upon the degree of compression pressure attained in the working fluid. When operating upon the Otto cycle the gas and air are compressed to as great a pressure as practicable and then are exploded, giving a still higher pressure. This same process can be employed in connection with a gas turbine and has been advocated for that purpose. Under this plan the air and gas would be compressed and exploded in a chamber lined with refractory material, and would then discharge through a diverting nozzle and impinge against the blades of a turbine wheel, as in the case of the De Laval

steam turbine. The diverging nozzle would act as an expansion nozzle, to reduce the pressure of the gases to atmospheric pressure and convert their potential energy into kinetic energy before doing work upon the wheel. The discharge would occur in puffs, an impulse being given as often as an explosion occurred.

Another method of accomplishing the result would be to have the combustion element burn continuously in contact with compressed air in a refractory chamber from which the heated air would discharge continuously through the expansion nozzle. The pressure in the chamber would remain constant under such conditions and the question of efficiency of the apparatus would depend solely upon the pressure that was attained through compression, as the relative amount of work done in an engine working upon this cycle does not depend upon the temperature of combustion. The efficiency of this cycle is not as high as that of the Otto cycle, but for turbine purposes would have the merit of giving continuous discharge through the nozzle instead of intermittent discharge. This plan of compression and then heating under constant pressure was employed in the well-known Brayton petroleum engine, one of the pioneers in the gas engine field.

The perfection of the gas turbine will not be an easy proposition. It will either have to be accomplished by individuals, working in a haphazard way through a long period of years, or by the concentrated efforts of some large firm like the General Electric Company. The latter plan will undoubtedly result in the quicker solution of the problem. One of the problems will be that of the temperature of the gas and its effect upon the metal of the turbine wheel. While the hot air will not come in contact with any of the bearings of the wheel, it is evident that the blades might not stand up to their work if subjected to a very high temperature. The fact that all bearings and wearing surfaces, however, would be removed from contact with the hot gases would undoubtedly make the water jacket unnecessary. —*Machinery.*

The Raising of Water from Deep Wells and Borings by Compressed Air.*

The use of compressed air for power transmission has been a matter of careful study and experiment on the part of engineers for some considerable time past, but it is only during more recent years that the "air-lift" system has been applied to any practical extent in this country.

The successful adoption of the system of raising water by the use of compressed air is dependent upon the conditions peculiar to the case under treatment, and it is therefore essential that the waterworks engineer, before resorting thereto, should carefully consider whether the special circumstances of the case are such as to fully warrant its adoption, and the author hopes in the course of the present paper to point out from his own experience what he believes to be the special circumstances to which the system is particularly applicable.

Before referring to the details of the plant—Corporation Waterworks, Tunbridge Wells—under the author's charge, it will be convenient briefly to review some of the general principles governing the operation of compressed air in raising water.

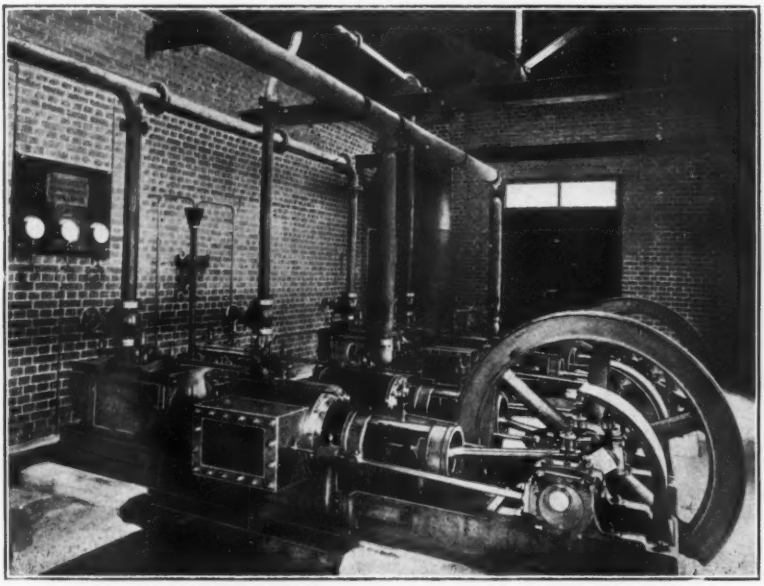
The experiments carried out in the United States by Dr. Pohlé, of Arizona, who for some years past has been engaged in the application and development of this system for raising water, oil and other liquids from underground sources, have proved that the main principle upon which the system operates is the following: Air under the necessary pressure, and of suitable volume, is admitted to the bottom of a pipe immersed in the water to be lifted in the manner shown on the accompanying sketch—Figure 1. By this means alternate bands or columns of air and water are formed in the water-pipe or "rising main," and the air does not, as might perhaps have been anticipated, pass through the mass of water. The result of this is that the aggregate weight of the water in the rising main is insufficient to balance the column of water in the boring, and the pressure of the latter therefore produces

* Paper by WILLIAM H. MAXWELL, Assoc. M. Inst. C. E., Borough and Waterworks Engineer, Tunbridge Wells, read at the Bolton meeting of the British Association of Waterworks Engineers.

an upward movement of the air and water column in the rising main. As the force lifting this column is the head of water at A—Figure 1—it follows that the height to which the water can be lifted depends upon the depth to which the pipe is immersed below the pumping level of the water in the boring, thus the higher the "lift" required the deeper must be the point at which the air is injected relatively to the normal water level therein, and so the height to which the water has to be raised determines the minimum depth to which the boring must be driven.

With regard to the best proportion between the immersion of the air nozzle and the "lift" of the water opinions vary, but the author found that in his case the most economical result was obtained when the ratio was 3 (of immersion) to 1 (of lift) at the start, and 2·2 to one at the finish of the test—see Table I. Under these conditions the efficiency worked out at 36·8 per cent. calculated from the steam diagram, and at 46 per cent. calculated from the compressor diagram, the volumes of air used and water lifted being in the proportion of 2·69 of the former to 1 of the latter.

From the results of his own tests and those of others, the author has prepared the following table showing the approximate horse-power required to compress one cubic foot of free air to different pressures per square inch:



COMPRESSED AIR MACHINERY FOR RAISING WATER FROM DEEP BORE WELLS AT TUNBRIDGE WELLS CORPORATION WATERWORKS.

	Pressure in lbs. per sq. in.	H. P. required to compress 1 cu. ft. of air.
1. Solvay Works, Saaralben	176	0.434
2. Brostowe Estate, near Friedheim.	140	0.376
3. Tunbridge Wells Waterworks	100	0.201
4. Ditto	80	0.189
5. Ditto	60	0.159
6. Sugar Factory, Glogau	45	0.145
7. Yard Works, Zwickau	30	0.121
8. Rossland Mines, B. C.	95	0.134†

† This excellent result was probably due to the use of intercoolers.

With regard to the quantity of air required to lift a given volume of water to any specified height, the author has found the following formula to give results in accordance with his own experience:

X = cubic feet of free air per minute;

A = gallons of water required per minute;

B = "lift" of water in feet;

$$X = \frac{A \times B}{125}$$

From this formula it is, of course, a simple matter to ascertain the quantity of water that can be lifted to any given height by a given quantity of air.

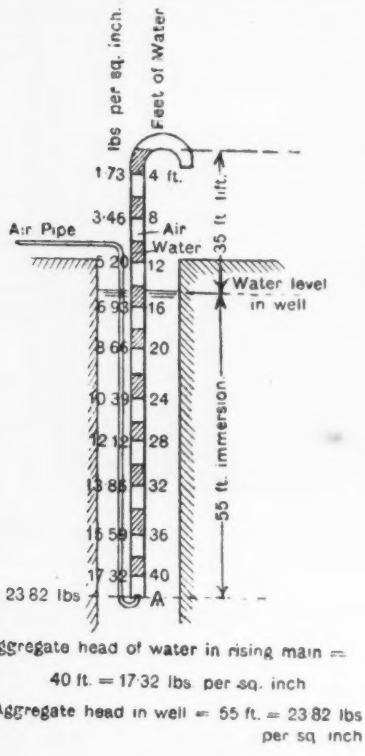


FIGURE I.

With regard to the proportions between the areas of the air-pipe and the rising main, the author considers that further experiments are required before it can be decided what proportions will secure the most economical results in practice; it is evident that the velocity of the water in the rising main is an important factor in this case, but as regards the air-pipe the author considers that the velocity of the air should not exceed about 20 ft. per second.

It has occurred to the author, as it has no doubt to others who have watched an air-lift plant in operation, that the excessive velocity and force of the discharge must involve a considerable waste of energy, and that some appreciable economy would be effected were it possible to utilize this force in any practical way.

In considering the design of the compressor, it is obviously important in the interests of economy to provide either "two-stage" or "three-stage" machines, with inter-coolers, according to the amount of compression required. Thus for pressures above 60 lb. per square inch and up to 300 lb. per square inch "two-stage" machines are most suitable, and from this to 1,000 lb. per square inch "three-stage" machines are desirable. The cooling of the air is also of great importance in this respect, and care should be taken to start with an air supply at the lowest temperature obtainable.

Description of Tunbridge Wells plant.—The main factor which influenced the decision to apply the "air-lift" system at Tunbridge Wells—which decision was arrived at prior to the author's appointment as waterworks engineer—was the possibility of operating the boring from the existing pumping station and avoiding the erection of any buildings, foundations or machinery requiring personal supervision at the site of the boring, which is situated some 530 yards away from the pumping station. The boiler power was also sufficient to supply the steam required for the compressors without any additional boilers, settings or buildings for same, and the air-compressing plant involved no extra attendance, as a new steam pumping plant was then being installed, and one extra mechanic was able to attend to both sets of plant.

The compression is carried out in two stages, the first to a pressure of 25 lb. per square inch, and the second, after inter-cooling, to the pressure required, which varies from 90 lb. to 100 lb. per square inch, according to the depth of the water in the boring. The air is delivered into a large steel receiver situated in the engine-house, whence it is conveyed to the wells

by means of a 4-in. cast-iron pipe. This main is formed of ordinary spigot and socket pipes with lead joints, which, however, shortly after starting the plant, showed signs of leakage adjacent to the receiver. This was traced to the expansion and contraction of the pipes due to the high temperature of the air, and was effectually prevented by fixing a cooler on the air-pipe between the second-stage compressor and the receiver.

There are two sets of engines and compressors designed to deliver a sufficient volume of air to lift the desired quantity of water, if needs be, over a standpipe 20 ft. high above ground level. The engines are compound, with cylinders 8 in. and 12 in. diameter, respectively, the air-compressing cylinders being 10 in., first stage, and 6 in. second stage, diameter, respectively. The stroke in each case is 14 in. The air cylinders are water-jacketed at sides and covers. The clearance in the air cylinders does not exceed 1 per cent. of the capacity. The air is drawn from outside the building and is carried in an earthenware pipe under the floor to the inlet valves, so that it enters the compressors at the lowest possible temperature.

The inter-cooler—between the first and second stages of compressors—is formed of a series of "Rows" tubes cooled by circulating water. This is also fixed outside the engine-house.

Provision is made for draining off the water which is precipitated in the receiver owing to the compression of the air, and, similarly, any oil carried forward by the air from the cylinders is also precipitated here, and drained away from time to time. As a further safeguard, another trap is provided near the boring for the same purpose. In some cases, however, the receiver is filled with coke in order to arrest any oil carried forward with the air.

The boring is 350 ft. deep, penetrating the Wadhurst Clay to a depth of 204 ft. 6 in., and the Ashdown sands to a further depth of 145 ft. 6 in. The upper portion is lined with 15-in. steel tubes, and the lower portion, 150 ft., with steel perforated tubes, 13½ in. diameter. The rest level of the water is about 96 ft. from the surface, and the pumping level, when drawing at the rate of 32,000 gallons per hour, is about 120 ft. from the surface, but on the cessation of pumping the water resumes its rest level very rapidly.

The water pipe or rising main is 7 in. diameter, and is carried to within a few feet of the bottom of the boring. The air pipe was originally 1½ in. diameter, but was subsequently increased to 2½ in. diameter, an alteration which reduced the air pressure required from 105 lbs. to 91 lbs. per square inch, the latter figure corresponding very closely to the head of water above the bottom of the air pipe, and thus proving the loss by friction to be reduced to a minimum. In a trial run for 10¼ hours made soon after the plant was installed, an average of 31,402 gallons per hour was raised from this boring under a head of 133 ft., whereas an ordinary single-acting pump, such as could be fixed in a boring of this small diameter, would not give more than about 18,300 gallons per hour. The plant was made and erected by Messrs. Hughes and Lancaster, of London and Ruabon, and the cost, including two compressors with compound engines, air main, air and water pipes in borings, condenser feed and air pumps, was £3374 17s. 6d.

Cost and efficiency of working.—In Table I. the author has given a summary of the results obtained by tests at various times and under different conditions of water level, which he believes will prove interesting. Here it will be seen that the most favorable result was obtained in trial I, when the proportion of immersion of air pipe to lift of water was 3 to 1 at the start, and 2·2 to 1 at the finish, the volume of air used per volume of water lifted being in the proportion of 2·69 to 1. The efficiency in this case was 36·8 per cent. calculated on the water raised proportionate to the indicated horse-power developed in steam cylinders and 46 per cent. calculated from the indicated horse-power shown by air cylinder diagrams. Unfortunately, on this occasion the fuel consumption was not recorded, so that the cost per 1,000 gallons of water raised could not be obtained.

From trial No. 5, however, with a much less immersion of air pipe, and when the proportion of air used to water lifted was more than double that in the former case, the cost of fuel worked out at 1·073d. per 1,000 gallons for a maximum lift of 125 ft. 9 in., the price of coal being 25s. 5d. per ton.

During the earlier months of the present year, with water levels varying between the depths of 98 ft. and 118 ft. below surface, under regular working conditions, the

TABLE I.—*Tests of Air Lifts—Tunbridge Wells Waterworks.*

1	2	3		4		5	6	7	8	9		10
Date of test.	No. of test.	Water levels below ground surface.				Average rate of delivery per hour in gallons.	Cubic feet of water delivered per minute.	Cubic feet of air per minute (atmospheric pressure.)	Volumes of free air to 1 of water.	Ratio of immersion of air pipe to lift.		
		Start.		Finish.						At start.		At finish.
		ft.	in.	ft.	in.							
June 3d, 1901	1	84	0	106	0	24,100	64·3	173·6	2·69	3·01	to 1	2·2 to 1
April 11th-17th, 1901	2	89	0	130	9	29,055	77·5	377	4·8	2·8	to 1	1·6 to 1
July (latter part), 1901	3	94	0	124	0	30,446	81·2	285·3	3·5	2·6	to 1	1·72 to 1
July 14th-26th, 1902	4	120	0	158	6	19,785	52·8	447	8·4	1·8	to 1	1·13 to 1
October 7th, 1902	5	103	9	125	9	27,636	73·7	421·8	5·7	2·27	to 1	1·69 to 1
October 21st, 1902	6	109	7	124	6	27,187	72·7	398	5·4	2·1	to 1	1·71 to 1
February 12th, 1903	7	96	6	112	8	26,289	70·1	260·5	3·7	2·46	to 1	1·95 to 1

NOTE.—The fuel cost per 1,000 gallons raised, test No. 5, with water levels varying between 103ft. 9in. and 125ft. 9in., was 1·073d., with coal at 25s. 5d. per ton. During the early months of the present year (1903), with water levels between 98ft. and 118ft. below surface, the fuel cost was ·97d per 1,000 gallons.

fuel cost came out at a fraction under 1d. per 1,000 gallons raised.

The comparatively unfavorable results shown in trial 4 were accounted for by the fact that at this time the water level was at an unusual depth, and the ratio of immersion to lift was consequently reduced to 1·13 to 1—end of trial. On this occasion a test was being made of the maximum yield of the strata, and all the wells and borings were being drawn upon to the utmost possible extent. In this case the quantity of air required per unit of water lifted rose to a proportion of 8·4 to 1, and the "efficiency" fell to 17·7 per cent. on the indicated horse-power in steam cylinders, and 22 per cent. on indicated horse-power in air cylinders. The cost of fuel—at 25s. 5d. per ton, as before—worked out at 1·53d. per 1,000 gallons raised. The author has given this result for the purpose of showing the effect of reducing the proportion of immersion to lift, but, of course, these figures must not be taken as representing the working of the plant under ordinary and fair conditions.

In trial No. 7 the efficiency worked out at 26·1 per cent. on steam cylinder diagram, and 32·5 per cent. on air cylinder diagram.

Table II. gives the working results obtained with four examples of air-lift plant on the Continent.

Table III. gives hourly records of a six-hour test carried out with an air-lift plant at Grinnel, Iowa, on August 16th, 1902. In this case the lift was exceptionally great, being 258 ft. The water main was 3½ in. diameter, and the air pipe fixed outside the water main was 2 in. diameter. The boring was 2,000 ft. deep, and the air pipe extended to a depth of 557 ft., thus giving an immersion of 299 ft., or a proportion of 1·16 to 1 of "lift." The water was delivered 3 ft. above surface level. The boring was lined with 10 in. diameter tubes into the rock, and was continued unlined of a diameter of 6⅝ in. The compressing plant was second-hand, and all pistons and valves were leaky, so that the air actually delivered was less than the piston displacement. The average efficiency worked out at 29·6 per cent.

At this boring a test was made with an ordinary pump, when the average rate of delivery was only 4,500 gallons per hour, compared to an average of 7,394 gallons per hour obtained by the air lift plant.

Comparison between different systems

TABLE II.—*Tests of Continental Air Lifts.**

Place.	—	Depth of immersion of air pipe in feet.	Height of delivery in feet.	Ratio of immersion to lift.	Diameter of rising main (inches).	Diameter of air pipe (inches).	Quantity of water raised in gallons per hour.	Water raised in gallons per minute.	Water raised in cubic feet per minute.	Quantity of air at atmospheric pressure, cubic feet per minute.	Volumes of air to 1 of water.	Mean pressure in air chamber, pounds per sq. inch.	I. H. P. of steam cylinder.	I. H. P. of air cylinder.	Ratio of work in air cylinder to work in steam cylinder (per cent.).	Cubic feet of air required at atmospheric pressure per gallon of water.	Ratio of H. P. in raising water to H. P. of air cylinder (per cent.).	Ratio of H.P. in water raised to I. H. P. (steam).	Velocity of water entering rising main, feet per second.	I. H. P. per cubic foot of air at pressure stated in Column No. 11.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sugar Factory at Glogau.....	1	95	42·75	2·22	6½	3	27,700	461·7	73·87	215	2·91	45¼	30·96	27·47	88·8	·465	22·3	19·3	5½	·144
	2	93	45	2·07	6½	3	37,000	616·7	98·7	280	2·84	44½	40·43	35·12	86·9	·454	24·3	20·8	7¼	·144
	3	95	42·75	2·22	6½	3	39,600	660·0	105 6	328	3·1	45½	50·15	42·54	84·6	·51	17·05	8		·153
	4	95	42·75	2·22	6½	3	40,000	666·7	106·67	425	3·98	48½	70·64	59·16	83·6	·654	14·8	12·2	8½	·166
Yard Works, Zwickau.....	5	63·25	45	1·4	$7\frac{9}{16}$	$4\frac{15}{16}$	53,700	895·0	143·2	348	2·43	30½	...	·42	...	·389	29·5	...	7½	...
Brostowe Estate, near Friedheim	6	301	203	1·48	2	1	2,190	36·5	5·84	28	4·8	139¼	...	10·52	...	·766	21·6	...	4½	...
Solvay Works, Saaralben.....	7	403	229	1·76	$2\frac{7}{16}$	$1\frac{3}{8}$	2,870	47·83	7·65	44·7	5·84	176	...	19·4	...	·938	20	...	4¼	...

* *Zeitschrift des Vereines Deutscher Ingenieure*, 3d September, 1898. Columns 3, 7, 8, 10, 17 and 19 have been added by the author.

TABLE III.—*Official Six-Hour Test of Air Lift made at the Waterworks of Grinnell, Iowa, August 16th, 1902.*

The well has the Pohlé system of piping, with a 3½ in. water pipe and a 2 in. air pipe placed outside the water pipe. The depth of the well is 2,000 ft., and the length of air pipe 557 ft. The lift is 258 ft.

Percentage of submergence = 53·6 per cent.
Gallons per minute (average) = 123
Cubic feet piston displacement = 135
Cubic feet air per gallon (average) = 1·09 (6·8 volumes air to 1 of water)
Percentage of efficiency = 29·6 per cent.

Time.	Gallons of water pumped.	Cubic feet of air per gallon.	Coal consumed.	Gallons of feed water.	Boiler pressure.	Air pressure.		Water level below surface.	
						Starting.	Working.	Normal.	Pumping.
			Pounds.		Pounds.	Pounds.	Pounds.		
One hour.	7,833	1·06	500	187	80	138	131	240	256
"	7,626	1·06	250	180	"	"	131	"	256
"	7,187	1·08	250	165	"	"	132	"	253·8
"	7,500	1·08	250	157	"	"	131	"	256
"	7,344	1·1	250	157	"	"	131	"	253
"	6,875	1·17	500	150	"	"	132	"	253·8

of pumping.—Having to provide a pumping plant for a boring of 15½ in. diameter and 400 ft. deep, situated in an isolated and somewhat inacessible position, the author has made a careful estimate of the comparative cost of pumping and maintenance with the three alternatives of (1) air lift; (2) steam engine; and (3) oil engine; both the latter operating ordinary borehole pumps, and in each case taking into account the capital charges involved. The results are shown in the following statement, the lift being assumed as 100 ft., and the working hours 3,000 per annum:

(1) *Compressed Air Plant.*

	Per 1,000 gallons.
Capital charges, labor and repairs..	1·16d.
Fuel as per test October 7th, 1902..	1·073d.
Total	2·233d.

(2) *Steam Engine and Borehole Pump.*

	Per 1,000 gallons.
Capital charges, labor and repairs..	2·4d.
Fuel—average of tests by the author.	0·5d.
Total	2·9d.

(3) *Cheap Fuel Oil Engine Plant and Borehole Pump.*

	Per 1,000 gallons.
Capital charges, labor and repairs.	1·53d.
*Crude oil fuel.....	0·25d.
Total	1·78d.

Advantages and disadvantages of air-lift system.—In conclusion, the author will summarize some of the most important general features of the air-lift system as ascertained from his own experience. The most suitable conditons under which the system may be applied appear to be those which exist at Tunbridge Wells, viz., where a boring is situated in an isolated and somewhat inaccessible position and the air-compressing plant can be placed on an existing pumping station, involving but little outlay in the erection of new foundations or buildings, or the purchase of additional land, and without incurring the provision of additional labor at the site of the boring. To secure satisfactory results, however, it is important that the difference between the rest level and the pumping level of the water should not be excessive; that the fluctuations of the same should be ascertained beforehand, and that the ratio between the immersion of the air pipe and the total lift of the water should be adjusted to the most suitable proportions, and not greatly varied in ordinary working.

Although it cannot be denied that the cost of fuel involved by the air lift exceeds that required with a steam or oil-driven pump of the ordinary form, yet the author believes that, under suitable conditions, the former will prove to be preferable, taking all charges into account in each case. The absence of any moving parts in the boring

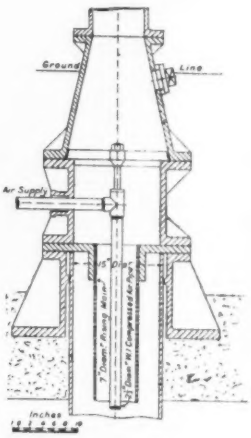


FIGURE 2.

secures a great reduction in the cost of repairs and maintenance, as well as in supervision and all other charges incidental to an additional pumping station. There is also a great advantage in the use of the air lift in cases where the water contains iron, as the aëration is carried out very thoroughly in the boring, and after the water has reached the surface the precipitation of the iron takes place more speedily. On the other hand, the system is by no means suitable to all circumstances, and should not be resorted to unless the conditions of working are specially favorable to its use.

*At a trial of a crude oil engine plant, working at Grantham, the cost of fuel averaged only 0·183d. per 1,000 gallons raised 100ft., the price of crude oil being 2¼d. per gallon.

Compressed Air Locomotive Haulage Plant.

In installing the compressed air haulage plant for the Homestake Mining Company at Lead, S. D., the primary object was to eliminate the fire risk incident to the use of steam locomotives, which had been used for this service for a number of years previous to the introduction of the present compressed air locomotive. The service for which this locomotive is used is to haul 2,000 tons of ore daily an average distance of from 1,200 to 2,000 feet, from the crushers at the hoists to the various stamp mills. This quantity of material is handled daily in from eight to nine hours. As previously stated, the primary object in using compressed air was the elimination of fire risk; but on account of the greater weight and power of the compressed air locomotive, a substantial reduction in the cost of operation has been effected, by accomplishing the required amount of work in one shift of eight or nine hours, in place of three shifts of eight hours previously required, when the work was performed by steam locomotives of less capacity, thus effecting a saving in wages of about $20 per day; and as the cost of fuel for operating the compressor is no greater than that required to operate the steam locomotives, this saving in wages is a clear gain. The plant has, it is said, exceeded the guarantees made for it by the contractors, the H. K. Porter Company, of Pittsburg.

The plant consists of:

One H. K. Porter Company compressed air locomotive; weight in working order, 27,600 pounds; cylinders, 9 inches in diameter by 14-inch stroke; driving wheels, four in number, 26 inches in diameter; rigid wheel base, 5 feet 3 inches; length over all, 18 feet; height, 7 feet; width, 5 feet 2 inches; gauge of track, 22 inches.

One three-stage, straight-line, Ingersoll-Sergeant steam-actuated air compressor; steam cylinder, 16 inches in diameter by 18-inch stroke; with double-acting intake air cylinder 12 inches in diameter by 18-inch stroke, compounded with two smaller single-acting air cylinders properly proportioned for a final pressure of 950 pounds to the square inch. The steam cylinder is equipped with Meyers adjustable valve gear, and the air cylinders with Ingersoll-Sergeant standard type of poppet inlet and discharge valves. All the compressing cylinders are water jacketed, and intercoolers of ample capacity are provided for cooling the air between the first and second and second and third stages of compression.

Two thousand feet of six-inch special pipe is used for the double purpose of conveying the air from the compressor to convenient charging station locations, and also to serve as a sufficient stationary storage to provide for the practically instantaneous charging of the locomotive. Except for the storage requirements, a much smaller size of pipe could have been used.

Air Cushion Resistance.

We have received the following question: "What would be the resistance to a piston entering a cylinder containing 5.95 cubic inches of air? The air would act as a cushion. The piston is 1.55 inches in diameter and enters the cylinder 3 inches. The total depth of the cylinder is 3.15 inches, so that there is .15 inch of clearance or of compression space at the end of the stroke. The piston, which is a good fit in the cylinder, travels a foot or more and makes 60 strokes a minute."

The resistance at the end of the stroke in this case would be so great as to be probably quite impracticable. The ratio of the initial and final volumes would be $.15 \div 3.15 = .0475$, and for this ratio of volumes the ratio of absolute pressures for adiabatic compression would be .0138. The absolute pressure when the piston entered the cylinder being 14.7 per square inch, the final absolute pressure would be $14.7 \div .0138 = 1065.21$, or the gauge pressure $1065.21 - 14.7 = 1050.5$. The area of the piston being $1.55^2 \times .7854 = 1.88$, the resistance at the end of the stroke would be $1050 \times 1.88 = 1{,}974$ pounds. This would be the theoretical resistance; the actual resistance, which it is impossible to determine in advance, would be considerably less than this, caused by the inevitable leakage of the piston. The mean resistance for the entire travel of the piston in the cylinder would be: $14.7 \div .0867 = 169.55$ pounds per square inch $\times 1.88 = 318.75$ pounds mean pressure on the piston. This also would be reduced by piston leakage. The unexplained factors used in this case are taken from an elaborate table on The Expansion of Steam and Gases in "Appleton's Cyclopedia of Applied Mechanics." This table was compiled by the late Richard H. Buel, C. E., and is invalu-

able for a wide range of computations relating to expansion and compression. It deserves to be better known and more generally employed.—*Am. Machinist.*

Notes.

The Engineer Publishing Company, Cleveland, Ohio, has purchased the publication *Steam Engineering* and consolidated that paper with the *Engineer*, beginning with the September issue.

A distinctive feature of the Midland Hotel, which has recently been opened at Birmingham, Eng., is the water supply, which is secured from a well sunk to a depth of 600 feet. The water is driven by compressed air in the storage tanks. Throughout the hotel the water is utilized for both sanitary and fire uses.

The second annual convention of the Master Steam Boilermakers' Association will be held in the Farmer's House, Chicago, October 7 to 10. Now that pneumatic tools have proved themselves so effective for riveting, compressed air has proved an important feature in the work of the boilermakers. As such it will undoubtedly figure more or less in the discussions at the convention.

The Cleveland Pneumatic Tool Company is now well established in its new plant at Cleveland, Ohio. The shop is located at Second and Hawthorne avenues, and is much better located and equipped than the old factory. The product of this company is not confined to pneumatic hammers alone, but drills, valve cranks, etc., are also made. The September 3d issue of the *Iron Trade Review* has an illustrated description of this plant.

The *Engineering Record* for September 5th contained a description of the new power plant of the Pittsburg-McKeesport and Connellsville Railroad, located near Connellsville, Pa. At this plant compressed air for the oil system is furnished by a Westinghouse steam compressor mounted on the engine-room wall and pumping into a storage tank in the basement. The oil return and drip pipes are fitted with connections at various points, and regularly blown out by the air blast. The compressed air is also employed for cleaning electric machinery and the switchboards. The pipe system extends to all parts of the power-house. The air is supplied to 100 pounds pressure.

A demonstration was recently made at Dolcoath, Cornwall, Eng., with water jet appliances for rock drilling. There were present at the time representatives and managers of a number of Cornish mines. The device revived, in what was claimed a more handy and practical manner, the principle of forcing water into the holes which was tried in Cornwall at the inception of rock drilling operations. This was subsequently allowed to lapse. It was claimed by some of the friends of Mr. Geo. J. Tyacke, of Camborne, Eng., that this appliance was his patent. This assertion is now contradicted by the Cornish *Telegram*, which states that Mr. Tyacke was under the mistaken impression that he could obtain a patent for the well-known principle of forcing water by means of compressed air, which was the substance of the device worked at Dolcoath.

In the construction of the subway under the Harlem river compressed air was used to assist in the construction of the tunnel. Owing to the treacherous nature of the soft material under the clay which would have to be penetrated for the working chamber, provision was made for using it. A two-stage compressor made by the Norwalk Iron Works Company was installed and so modified that it could be used as two separate low-pressure compressors ordinarily, but could be quickly changed to operate as a two-stage machine for high pressure if the need should arrive. The air was used at pressures only sufficient to correspond with the amount of water above the roof of the coffer dam or working chamber, which varied, of course, with the tides. This coffer dam or working chamber, which was built under water in a trench, proved successful and there was little trouble in the erection of the tubes and concrete walls.

An interesting application of compressed air was recently shown on board the submarine boat "Protector." With the aid of pneumatic pressure a diver recently dropped from this boat without admitting a drop of water into the interior of the vessel. The diving apartment, which is 8 feet in length, is at the bow of the submarine boat. The diver and his assistant went into it, and after the door in the bulkhead was hermetically sealed, compressed air was forced into the chamber until a pressure of 18 pounds to the square inch was obtained. This was sufficient, when the trap in the bottom, 12 feet below the surface, was open, to keep the water out. This arrangement serves two purposes. In case the "Protector" becomes so disabled that it can not rise, the crew can escape through the trap door and ascend to the surface of the water. Through the diver's chamber, also, men can be sent to the bottom of harbors to cut wires connected with submarine mines or telegraph cables.

Two recent contracts by the Union Switch & Signal Company are those for the Interborough Rapid Transit Company (Subway), of New York, and the North Shore Railway, of California. The Westinghouse electro-pneumatic system is to be installed on the first named, but a new feature is to be introduced, that of using alternating current. It is obvious that the use of track circuits on third-rail roads, where the rails are used for the return circuit, and at the same time for the signalling circuit, introduces what may be serious complications. In order to avoid these difficulties, the signals will be controlled by alternating current, through relays that are sensitive to alternating current only, and which will not be affected by the direct current used for train service in the subway. On the North Shore Railway, which runs about thirty miles north from Sausalito, California, across the bay from San Francisco, the electric semaphore system of automatic block signals is to be used with a track circuit. This being a high tension third-rail electric road, alternating current will be used for the signal system.

An important project is that now in progress by the Vancouver Power Company. That company is building an electric plant for the purpose of supplying the city of Vancouver with power. The electricity is generated by water-power which comes from two deep lakes. They are to be connected by a tunnel which is now being constructed. The tunnel is 9 feet wide by 9 feet in height, with round corners, and is being driven from both ends by compressed air drills. Before the machine drills and air compressors arrived, hand drills were used and the forward progress was 2 feet per day at each end, but since the installation of these machines this has been increased to 10 feet per day. The plant at each end includes a 100 horse-power boiler, a 60 kilowatt 500 volt generator and a 4 drill two-stage Leyner air compressor. Rand drills are used in the headings. The ventilation is provided for by a 12-inch galvanized iron pipe through which the air is exhausted by means of an air-jet under 100 pounds pressure, acting as an injector. This is only put in operation for a few minutes after each blast to remove the smoke, the exhaust from the air drills furnishing all the fresh air necessary at other times.

That portion of the South African gold fields known as the Rand is now recovering from the effects of the Boer war, during which many of the mining plants were partially if not totally destroyed. The Kleinfontein Mine, which suffered severely, has been consolidated with the Kleinfontein Central Mine, the new undertaking being called the New Kleinfontein Mine, and a complete new plant erected. The air compressing plant suffered as well as the rest, and is now being rebuilt by the firm of Walker Bros., of Wigan. It consists of a two-stage compressor arranged to compress the air up to 80 pounds per square inch, and to furnish sufficient air at that pressure to drive fifty rock drills 3¼ inches in diameter. The air compressors are directly connected to the steam engine which drives them. The steam engine is also compound, and works with steam superheated from 500 to 550 degrees F. The steam cylinders are 55 and 28 inches in diameter and the air cylinders 48 and 30 inches in diameter, with a 60-inch stroke. The valve gear of the steam engine is of the Corliss type, controlled by a governor.

Another compressor was partially wrecked. The same firm is now installing the new low-pressure side for this

compressor. When the work of reconstruction is completed this will be one of the best-equipped mines in South Africa.

In the erection of the Atlantic avenue viaduct, which is designed to carry the Long Island Railroad over and under street grades from the old Brooklyn city limits to the Flatbush avenue station, Brooklyn, practically all of the riveting was done by compressed air. As soon as the girders were set in position the erectors are followed by six gangs of four men each operating Chicago pneumatic riveters. There were 650 7/8-inch field rivets in each panel, and each gang drove about 200 rivets in eight hours, these together finishing about two panels a day.

The pneumatic hammers were operated by air at a pressure of 120 pounds supplied by a portable compressor plant set up on the ground under the completed structure and occasionally moved forward as the erection progressed. This plant was of special design and exceedingly compact and simple in construction, being calculated for service under any ordinary circumstances and to be transported and operated with the greatest possible ease. The 8¼-inch by 12-inch Ingersoll-Sergeant compressor had a capacity of 650 cubic feet of free air per minute, sufficient to operate seven pneumatic hammers, and was seated on a 4-foot by 10-foot steel platform, which also supported the 13 horsepower Dale engine. At one end there are three transverse horizontal 18-inch air receiver tanks, each 4 feet long, which were connected together and set behind the flywheel.

The Chicago Pneumatic Tool Company has issued the following official statement regarding certain stories about that concern which have been repeated and published of late:

"In the first place, President Duntley is not going to resign. It is due to his knowledge, energy and ability that the pneumatic tool business has grown to its present vast proportions. This is fully recognized by the directors, and none of them desire his resignation. The report that he does not have the confidence of Mr. Schwab or Mr. Matthiessen is entirely without foundation, and there is no justification in the report that he anticipates retiring or that any stockholders desire him to do so.

"The fact that Mr. Schwab has purchased from Mr. Pam the stock owned by the latter is true, and this transaction was a private one between them. It originated with them, and none of the other officers or stockholders had anything to do with it. Therefore, Mr. Pam, having sold all of his stock, it naturally followed that he should resign from the directors, which he has done entirely of his own accord. The above transaction is but one of the many which are continually passing between Mr. Schwab and Mr. Pam, and has no significance whatever. The fact that Mr. Matthiessen is at present in Chicago is true, but he is not examining the accounts of the affairs of the company; simply attending to other affairs in which he is interested. The executive offices of the company are to be moved to New York, and it is due to this fact that some of the directors have tendered their resignations. Mr. Schwab is the largest stockholder in the company, and has expressed a desire to take an active part in the direction of the company's business, as has also Mr. Matthiessen. Their action is entirely justified by their present holdings in the company, and as they both live in New York, it is necessary that the executive offices be located in that city.

"As regards Messrs. Wacker, Chalmers and Lynch, these gentlemen agreed when they accepted places on the board that they would do so only if the executive offices were located in Chicago, as it would be impossible for them to attend meetings in New York City, as they could not take the time from their other affairs. Naturally, therefore, when they learned of the proposed change in location they were opposed to it, as they felt it impracticable for them to continue on the board and executive committee, and they accordingly tendered their resignations. There is no other significance whatever attached to their resignations. In all probability the number of directors will be reduced from fifteen to nine, as the members are widely separated and it is difficult to obtain a quorum with the present number. The affairs of the company are in a most flourishing condition and the prospects are exceedingly bright for them to continue so in the future. The various plants are working increased forces in order to adequately ful-

fill the requirements. Their foreign offices report a correspondingly cheerful outlook. The business for the month of August just past exceeded that transacted in August, 1902, and there is every indication that the present month of September will be very satisfactory as regards sales of pneumatic appliances."

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U.S. PATENTS GRANTED AUG., 1903.

Specially prepared for COMPRESSED AIR.

735,217. PNEUMATIC APPARATUS FOR PRODUCING MATS OR BATS OF FIBROUS MATERIAL. Julius De Long, Brooklyn, N. Y. Filed Dec. 6, 1902. Serial No. 38,876.

An apparatus for producing mats or bats of fibrous material, the combination with a molding-chamber the walls of which are constructed to impart any desired shape, size or contour to the mat or bat in transverse cross-section, of means for producing a current of air for conveying fiber into said molding-chamber and packing and molding it therein.

735,544. AIR-BRAKE SYSTEM. William B. Mann, Baltimore, Md. Filed June 3, 1903. Serial No. 159,920.

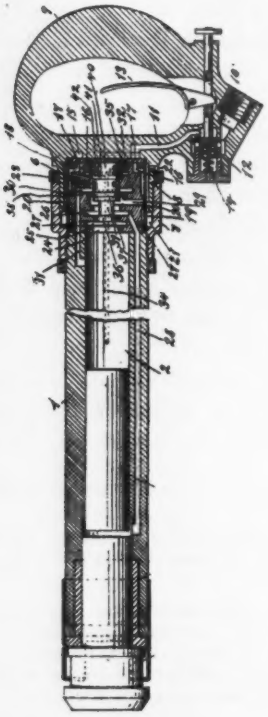
An air-brake system, the combination of a plurality of connected storage-tanks containing compressed air, and automatically-operating means preventing the escape of air therefrom when said tanks are disconnected.

735,909. PNEUMATIC PASSAGE-WAY. John G. Rehfuss and Martin O. Rehfuss, Philadelphia, Pa., assignors to the Bureau Can and Manufacturing Company, of Delaware. Filed Dec. 27, 1902. Serial No. 136,852.

A pneumatic passage-way, rectangular in cross-section, and provided with inwardly-bent guide members projecting from its opposite parallel walls forming contracted passage-ways for the travel of articles between the free ends of said guide members, as set forth.

735,861. PNEUMATIC-TUBE SYSTEM. Wilbur G. Davis, Newton, Mass., assignor to the Single Tube Transmission Company, Boston, Mass., a Corporation of Maine. Filed Dec. 1, 1902. Serial No. 133,351.

735,589. IMPACT-TOOL. Charles B. Richards, Cleveland, Ohio, assignor to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Original application filed Dec. 24, 1900, Serial No. 41,005. Divided and this application filed Feb. 20, 1902. Serial No. 94,923.



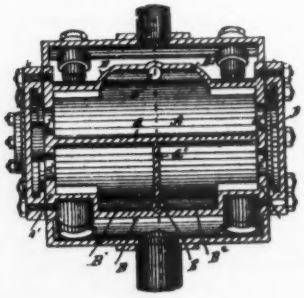
An impact-tool, the combination with a plunger-cylinder having air-distributing ports and channels at both ends and having the inner end exhaust a distance from the inner end, and a plunger reciprocating in said cylinder, of a valve-chamber having one end open to the inner end of said cylinder, a valve in said chamber and having one end exposed to the pressure at said cylinder end, and a leak-passage from the live-air inlet to such exposed end of the valve.

735,981. RAILWAY AIR-BRAKE. Peter Jacobson, Milwaukee, Wis. Filed May 18, 1903. Serial No. 157,514.

736,253. AIR - COMPRESSOR GOVERNOR. James H. Herron, Erie, Pa., assignor to Herron & Bury Manufacturing Company, Erie, Pa., a Corporation of Pennsylvania. Filed Oct. 6, 1902. Serial No. 126,220.

The combination, with a compressed-air receiver, and plunger-cylinders provided with plungers for raising the valves of an air-compressor; of a governor-valve case, a pipe between the said valve-case and receiver, pipes between the said valve-case and cylinders, a valve-shell secured in the said case and provided with holes arranged in pairs and a loaded governor-valve slidable inside the said valve-shell and normally connecting the said cylinders with the atmosphere, said valve and its case being provided with suitable air-passages substantially as set forth which operate normally to connect the said cylinders with the atmosphere through one pair of holes in the said valve-shell and to connect the said cylinders with the said receiver when the said valve is slid from its normal position by the pressure of the air in the said receiver through the other pair of holes in the said valve-shell.

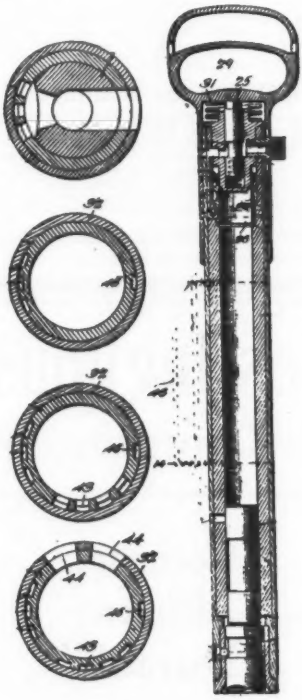
736,254. AIR - COMPRESSOR - CYLINDER WATER-JACKET. James H. Herron, Erie, Pa., assignor to Herron & Bury Manufacturing Company, Erie, Pa., a Corporation of Pennsylvania. Filed Nov. 4, 1902. Serial No. 130,049.



The combination of an air-compressor cylinder, radially-projecting flanges on the ends thereof having openings therein, chambered

cylinder-heads secured to said flanges and communicating with the openings therein, a water-jacket having water-inlet and water-outlet openings therein surrounding said cylinder and secured to the peripheries of the flanges thereon, longitudinal and annular ribs between the cylinder and water-jacket whereby the water entering the inlet-opening of the water-jacket is compelled to travel predetermined paths along the cylinder and through the cylinder-heads before passing out of the outlet-opening in the water-jacket.

736,555. PNEUMATIC TOOL. Charles H. Shaw, Denver, Colo. Filed Nov. 11, 1901. Serial No. 81,937.



A pneumatic tool, the combination of the cylinder having at one end an annular valve-chamber of a diameter greater than the bore of the cylinder, said chamber having two concentrically-disposed shoulders arranged in different planes, a peripherally-ported annular valve guided within the chamber and adapted to fit against said shoulders, said valve having a central bore of a diameter equal to the bore of the cylinder and the area of the lower face of said valve being less than the area of the upper face thereof, means for closing the upper portion of the valve-bore to form a dead-cushion space within the valve, a piston adapted to enter the bore of the valve after leaving the cylinder and to effect an opening movement of said valve by the compression of air during the latter portion of the piston stroke, the valve-opening movement being in the same direction as that in which the piston is traveling, a piston-controlled port leading to the valve-chamber, longitudinal ports or passages formed in the valve between one of the peripheral ports and the upper end of said valve to permit the entrance of air under working pressure to said valve-chamber, and ports or passages leading through the walls of the cylinder and controlled by said valve.

736,398. AIR-PUMP. Louis E. Hoffman, Cleveland, Ohio. Filed Nov. 20, 1902. Serial No. 132,087.

An engine, the combination with the air-pump having a notched oscillatory pump-rod, and a lever actuated by a reciprocatory part of the engine, having a projection adapted to engage the notch of an engaging gear, including a lever under control of the operator, and a connecting-rod between the lever and the pump-rod extensible to accommodate variation in distance due to the reciprocation of the pump-rod.

736,680. PNEUMATIC TUBE. Louis G. Bostedo, Chicago, Ill., assignor to Bostedo Pneumatic Tube Company, Chicago, Ill., a Corporation of Illinois. Filed May 17, 1897. Serial No. 636,974.

A pneumatic-tube system, the combination, with a main tube and its branch, of carriers, a pivoted switch for diverting the carriers from the main tube into the branch, a cylinder closed at both ends and having a piston operatively connected with the switch, a motor-fluid-supply pipe connected with the main tube and having branch pipes connected with the opposite ends of the cylinder, a valve controlling the supply of motor fluid to said branch pipes, whereby either end of said cylinder may be placed in communication with the main tube, a selective device, separated devices on the respective carriers for operating the selective device, and mechanism intermediate the selective device and the valve for shifting the valve and switch, substantially as described.

735,549. SUCTION-VALVE FOR COMPRESSORS. Ernest A. Menking, Pittsburg, Pa. Filed Mar. 6, 1903. Serial No. 146,500.

A valve structure for compressors and the like, comprising an internally-threaded ring having a valve-seat, a valve having a stem provided with a head, an inclosing cage constructed of substantially semi-cylindrical sections, each formed externally with semi-cylindrical projections, which are flush with said ring, and each also having a semi-cylindrical internal extension, the two latter uniting to form a guide for the stem, a spring surrounding the guide, said guide having recessed portions constituting a bearing for one end of the spring, and a bearing for the other end of said spring, adapted to be applied over said head, said cage-sections having another internally-threaded ring surrounding the same adjacent the head, and each section having a semi-cylindrical threaded extension at each end to receive said first-named ring and the ring last named.

736,778. AIR-PUMP. Walter M. Reason, Pontiac, Mich. Filed Dec. 14, 1901. Serial No. 85,926.

736,958. PNEUMATIC CLOCK. Ernest Girod, Hounslow, England. Filed Sept. 12, 1902. Serial No. 123,156.

An apparatus of the class described consisting of the combination of an air-compressor operated by water-pressure, an air-motor, a pair of guided weights, a pivoted cross-head on the air-motor adapted to life each of the two weights alternately, a clock, a pipe leading to time-indicating dials, valves for distributing air to the air-motor and said pipe, a weighted lever adapted to urge the clock, a rotating shaft, cams thereon adapted to open and close the said valves, and a mechanism adapted to permit the weights lifted by the air-motor to rise freely and in descending to drive the camshaft.

736,986. AIR-PUMP. Jay B. Lyford and Charles E. Hartman, Bridgeport, Conn. Filed Feb. 25, 1902. Serial No. 95,601.

737,363. PNEUMATIC MOTOR-VALVE MECHANISM FOR AUTOMATIC PIANO-PLAYERS. Thomas Danquard, New York, N. Y., assignor to Kohler & Campbell, New York, N. Y., a Firm. Filed Apr. 26, 1902. Serial No 104,739.

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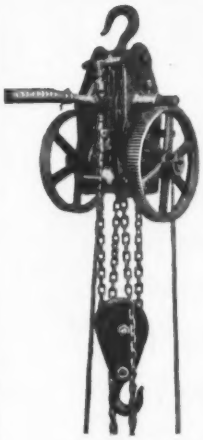

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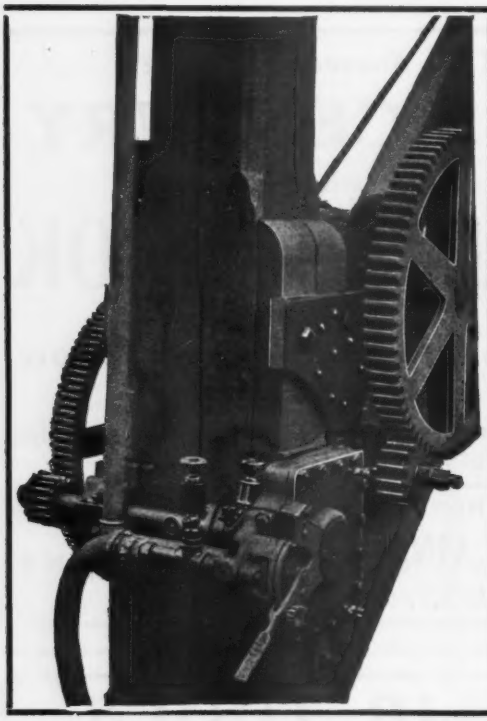

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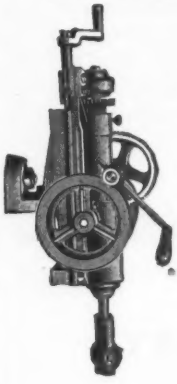

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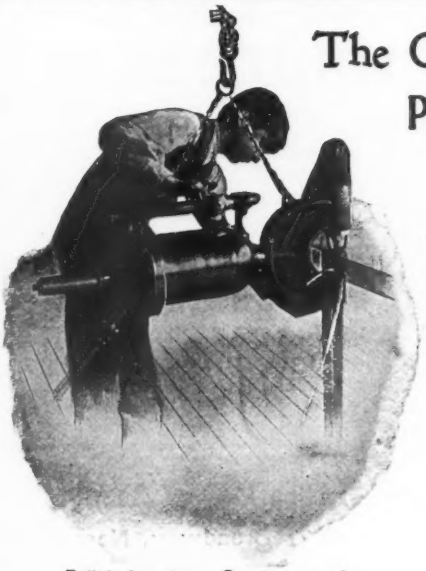

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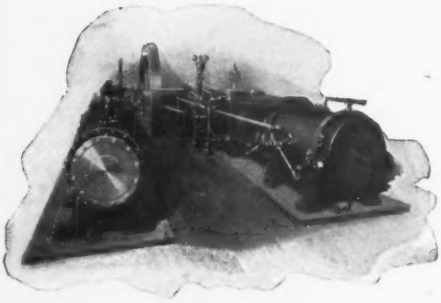

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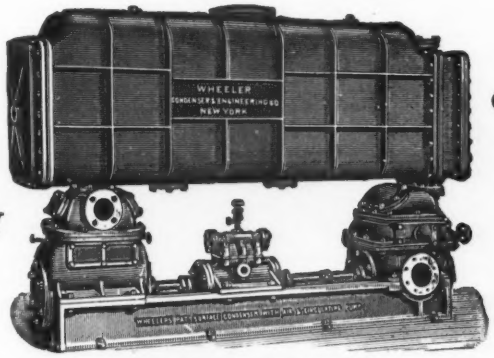

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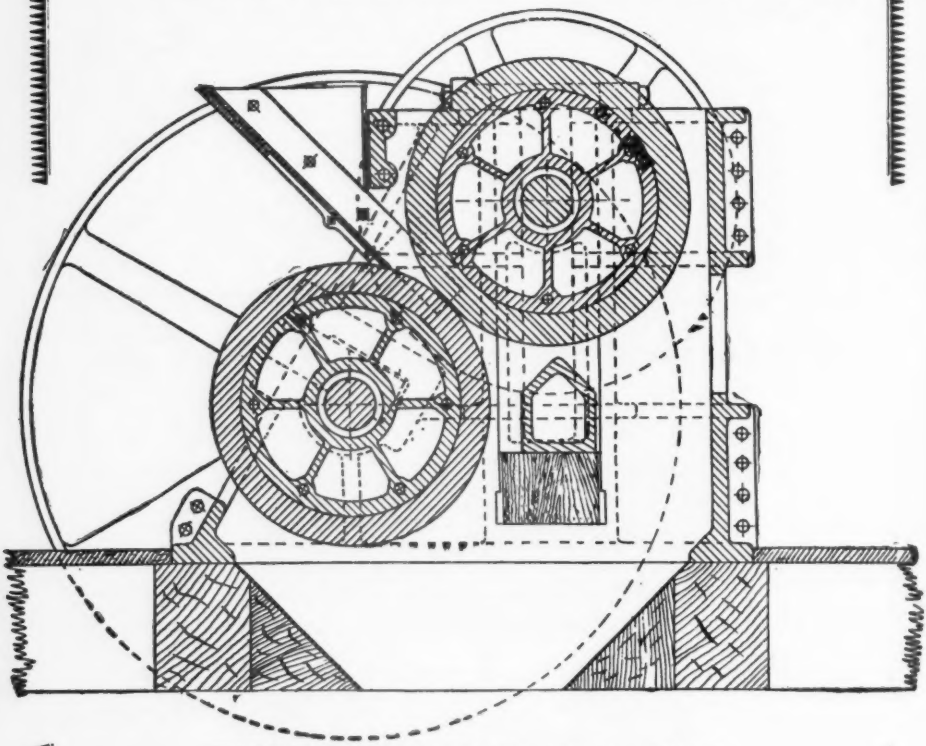

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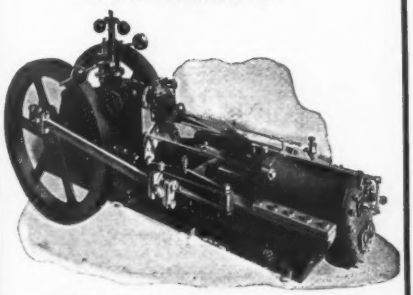

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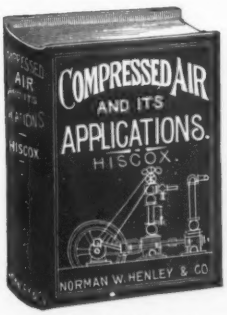

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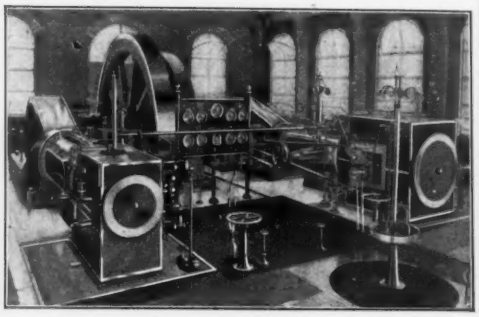

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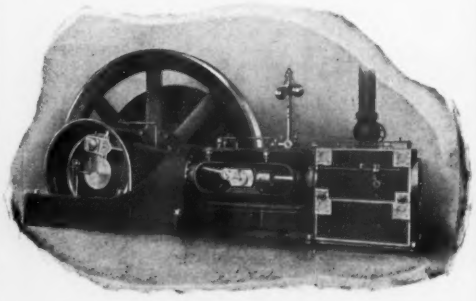

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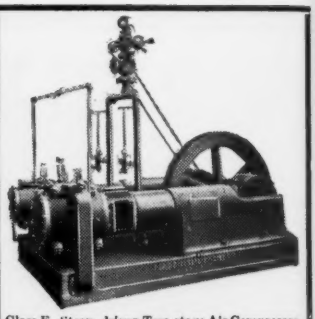

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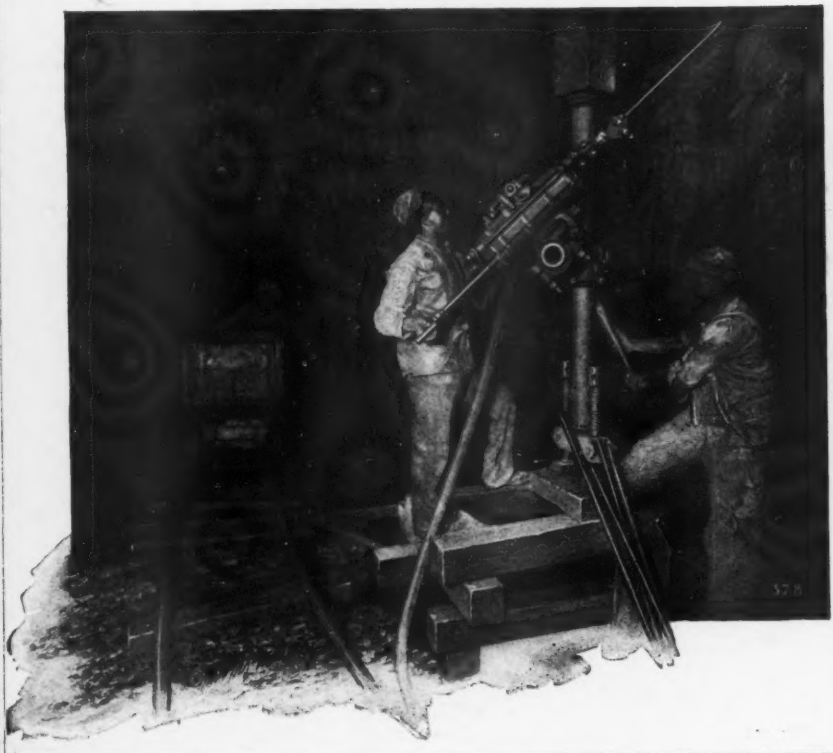

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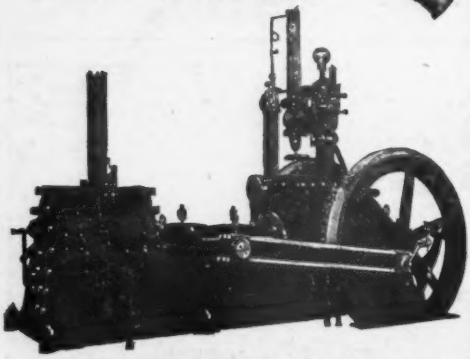

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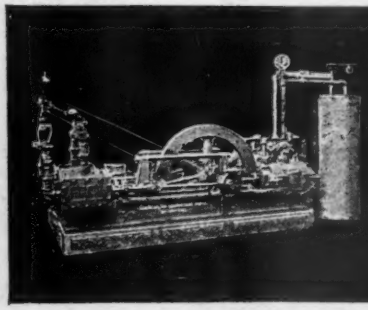

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